MONITORING OF DOWNSTREAM SALMON AND STEELHEAD AT FEDERAL HYDROELECTRIC FACILITIES - 1988

Annual Report

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T A B L E O F C O N T E N T S

INTRODUCTION

The seaward migration of salmonid smolts was monitored by the National Marine Fisheries Service (NMFS) at four sites on the Snake-Columbia River system in 1988. This project is a part of the continuing Smolt Monitoring Program to monitor Columbia Basin salmonid stocks coordinated by the Fish Passage Center (FPC) for the Columbia Basin Fish and Wildlife Agencies and Indian Tribes. This program is carried out under the auspices of the Northwest Power Planning Council Fish and Wildlife Program and was funded by the Bonneville Power Administration (BPA).

Sampling sites were Lower Granite, McNary, John Day and Bonneville Dams (Figure 1). Data from these sites provided information required by the Fish Passage Managers (FPM) of the FPC for flow and spill management for fish passage during the migration season. Post season analysis of this information by the FPC provides travel time and migration timing information. Smolt Passage was monitored at these sites by: 1) systematic sampling of the smolt migraticn from late March through late July at Lower Granite Dam, late March through late September at McNary Dam, April through October at John Day Dam, and mid March through late November at Bonneville Dam; 2) recording brands; and 3) daily reporting of all pertinent fish capture and ccndition data, as well as dam operations and river flow data for passage estimates and travel indices to the FPC Fish Passage Data Information System (FPDIS).

METHODS AND MATERIALS

Monitoring the smolt migration at Lower Granite and McNary Dams was as reported for 1984 (Johnsen, et al., 1984). A portion of the total number of smolts from the gatewell collection system at each project was sampled by time at a target rate of "...the lesser of 3% of the estimated weekly outmigration or, 10% of the weekly tctal of the smolts collected or bypassed....", based on the FTOT Annual Work Plan for 1988. At McNary Dam some increase above the target rate was allowed to collect sufficient numbers of yearling spring chinock smolts to mark for the needs of the transport evaluation study. (Details to be reported in the 1988 FTOT annual report). Monitoring activities at Lower Granite Dam were performed jointly with the Washington Department of Wildlife.

Sampling methods at John Day Dam were the same as 1937; the airlift pump system in unit 3 (gatewell B) was utilized.

At Bonneville Dam sampling in powerhouse 1 (PH 1) was by dipnetting (DN) a gatewell (9B) using a dipnet basket of the type described by Swan, et al. (1979), during the spring migration and by utilizing the downstream migrant trap (DSM) in the collection channel in PH 1 and

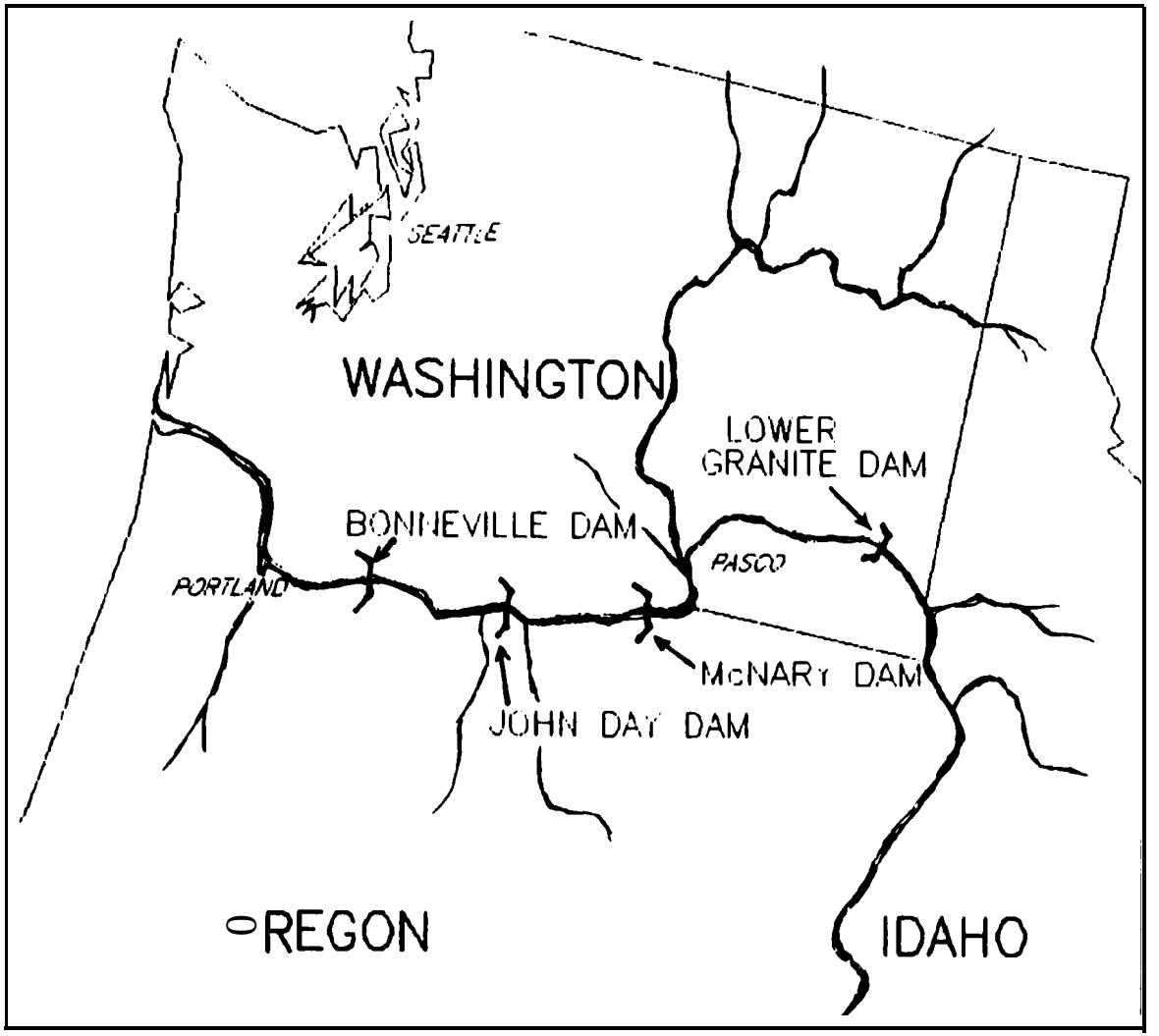

FIGURE 1. N.M.F.S. Smolt Monitoring Sites on Columbia/Snake River Systems

PH 2 during both the spring and summer/fall migrations. (The DSM and sampling methods were described by Gessel, 1986, and by McConnell and Muir, 1982, for PH 1 and PH 2 respectively). Flow data were obtained from the Corps of Engineers (CoE).

The Sampling periods are shown in Figure 2. Sampling frequencies for the different sites are as follows:

Lower Granite Dam -- Daily; 24-hour cumulative sample. 3/25 to 7/25.
McNary Dam --------- Daily; 24-hcur cumulative sample. 3/25 to 9/21.
John Day Dam ------- Daily; 24-hourly samples. 3/30 to 10/31.
Bonneville Dam
?H 1, dipnet -- Daily; 24-hour cumulative sample. 3/16 to 6/30.
PH 1, DSM ---- Seven days per week; 8 hourly samples plus periodic die1 samples, 3/15 to 11/30.
PH 2, DSM2 ---- Seven days per week; 24-hour cumulative sample, 3/17 to 11/30.

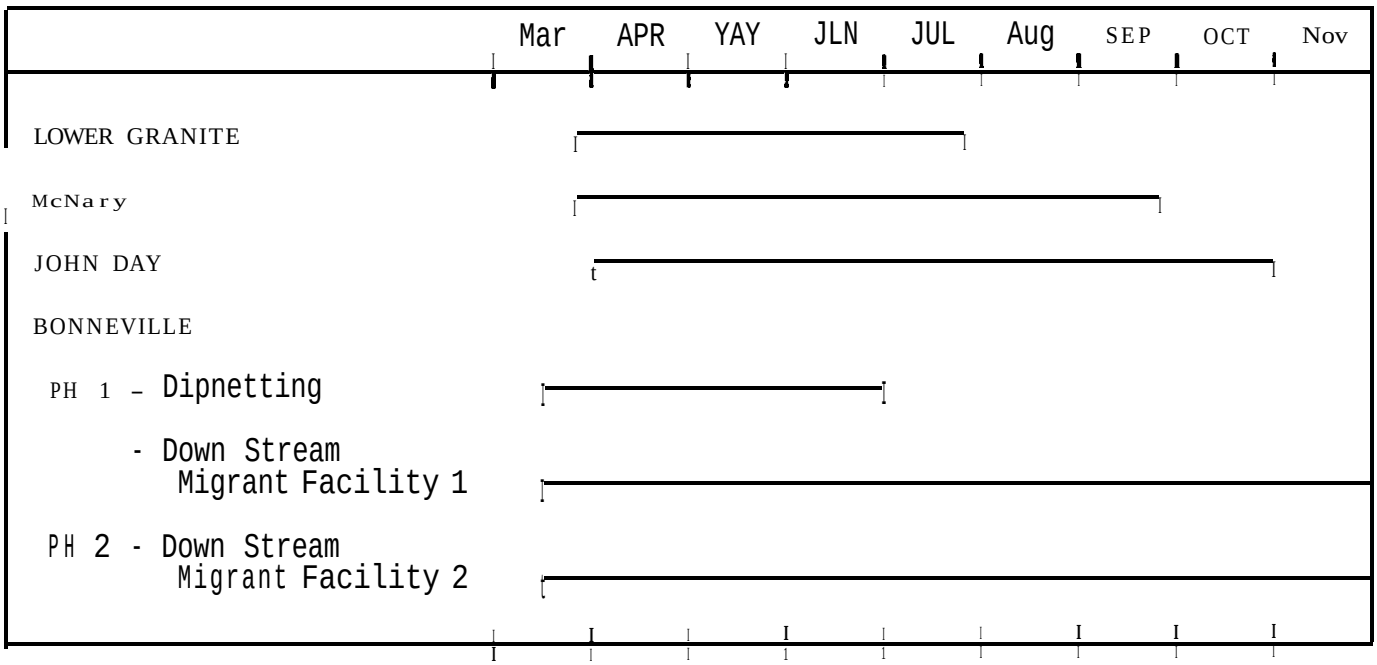

FIGURE 2. Smolt monitoring season by site, 1988.

RESULTS AND Discussion

Sampling results for field season 1988 are presented in Table 1. The results of the hands-on assessments of smolt movement into or through the hydroelectric facilities at the listed sites are summarized. Included in the appendices is a graphic coverage of the passage index with flow for Lower Granite and McNary Dams, die1 and seasonal passage and flow at John Day Dam and capture patterns and flow at Bonneville Dam. Some duplication may occur in other summaries.

LCWER GRANITE Dam

Lower Granite Dam monitoring activities this season were essentially the same as in 1987, except that, due to expected low flows, transport marking was cancelled. This greatly simplified the management of sampling operations. No significant operational problems were encountered through the season.

The preanesthetizer (PA) system as modified in 1987 functioned well, and continues to be a significantly beneficial system. Preanesthetization of sample fish increases their survival (Matthews et al., 1985) and it is easier and quicker for sorters to examine them. Additional lighting was installed this year over sorting troughs and we believe this improved accuracy in sample processing.

Flows and the chronological smolt passage pattern are presented for Lower Granite Dam in Appendix A. The inclusive dates for the 10 to 90 percent segment of passage for chinook smotts were 4/18 to 5/24 and for steelhead, 4/27 to 6/2. Passage of other salmonid species were of substantially lower numbers (~0.1% of the total sample).

McNARY Dam

Monitoring activities at McNary Dam were routine and essentially the same as 1987. Minor improvements to the sample holding tank floor, PA (knife) gates, and addition of an electric powered crowder by the CoE helped in making the PA and delivery system to the inside sorting troughs a more efficient system to operate; additional operator experience was also beneficial.

The benefits of the PA system continue to be evident in 1988 as shown by the low delayed mortality (43 hr. holding). Tests of a subsample of marked fish (CWT, branded and adipose clipped) averaged 0.4% delayed mortality for both "juvenile spring and fall chinook salmon" (Matthews, 1988). This compares favorably with the 0.5% and 0.3% delayed marking mortality of "spring and summer/fall chinook salmon respectively'* in 1987 as reported by Matthews, et al., 1988. Matthews

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1 No distinction was made between yearling and subyearling chinook smolts at Lower Granite Dam.

TABLE 1. -- Summary of 1988 smolt sampling activities at Lower Granite, McNary, John Day and Bonneville Dams.

SPECIES	SITE	TOTAL SAMPLE	BRANDS IN SAMPLE	ESTIMATED[1/] COLLECTION	ESTIMATED[2/] PPI
YEARLING CHINOOK	LOWER GRANITE[3/]	82,408	2,994	2,798,892	2,798,892
	McNARY	280,735	17,813	2,971,263	2,971,263
	JOHN DAY	34,045	2,262	34,045	408,675
	BONNEVILLE PH#1 DN[4/]	35,426	523	35,426	406,352
	BONNEVILLE PH#1 DSM	28,955	425	391,479	365,812
	BONNEVILLE PH#2 DSM	7,068	56	7,068	N/A
SUBYEARLING CHINOOK	LOWER GRANITE[3/]	N/A	N/A	N/A	N/A
	McNARY	359,152	3,254	6,884,478	6,884,478
	JOHN DAY	109,448	1,797	109,448	363,101
	BONNEVILLE PH#1 DN	30,415	83	30,415	333,165
	BONNEVILLE PH#1 DSM	96,413	165	580,644	724,102
	BONNEVILLE PH#2 DSM	9,744	2	9,744	N/A
STEELHEAD	LOWER GRANITE	136,103	1,267	4,750,053	4,750,053
	McNARY	82,572	9,788	822,946	822,946
	JOHN DAY	14,985	395	14,985	179,233
	BONNEVILLE PH#1 DN	4,037	115	4,037	53,354
	BONNEVILLE PH#1 DSM	7,473	157	75,662	103,761
	BONNEVILLE PH#2 DSM	762	8	762	N/A
COHO	LOWER GRANITE	0	0	0	0
	McNARY	21,667	33	213,144	213,144
	JOHN DAY	8,650	3	8,650	109,325
	BONNEVILLE PH#1 DN	33,005	2	33,005	445,849
	BONNEVILLE PH#1 DSM	40,750	1	419,286	599,194
	BONNEVILLE PH#2 DSM	5,555	1	5,555	N/A
SOCKEYE	LOWER GRANITE	101	0	2,199	2,199
	McNARY	23,157	578	251,746	251,746
	JOHN DAY	6,333	80	6,333	80,406
	BONNEVILLE PH#1 DN	1,690	21	1,690	24,141
	BONNEVILLE PH#1 DSM	4,587	55	52,023	77,921
	BONNEVILLE PH#2 DSM	238	4	238	N/A
TOTAL CATCH	LOWER GRANITE	218,612	6,261	7,551,144	7,551,144
	McNARY	767,283	30,471	11,143,577	11,143,577
	JOHN DAY	173,461	5,037	173,461	1,640,596
	BONNEVILLE PH#1 DN	104,573	744	104,573	1,262,859
	BONNEVILLE PH#1 DSM	178,178	804	1,429,094	1,870,730
	BONNEVILLE PH#2 DSM	23,367	71	23,367	N/A

Data Source: Fish Passage Data Service, released Jan. 5, 1989.

1/ Collection counts are adjusted for the sample rate at Lower Granite and McNary Dams only. Total counts may vary from other published summaries because of different time periods for daily estimates.

2/ Passage Index is collection count adjusted for rate of flow.

3/ No distinction was made between Yearling and Subyearling Chinooks at Lower Granite Dam.

4/ DN = dipnetting; DSM = DownStream Migrant facility.

(op. cit.) also contrasts delayed marking mortality in 1987 with the 3.5% mortality of "spring/summer chinook salmon" experienced in 1986, the year prior to the installation of the "new combination sample/pre-anesthesia tank".

Flows and the chronological passage pattern for McNary Dam are listed in appendix B The inclusive dates for the 10 to 90 percent segment of passage are:

Chinook yearling	4/18 - 5/22
Chinook subyearling	6/15 - 7/18
steelhead	4/30 - 5/30
Coho	5/16 - 5/31
sock	5/4 - 5/26

Notations of the occurrence and estimates of chinook fry (subyearling < 60 mm) were made for comparison with the nearly one-half million noted in 1986. This season (1988) chinock fry comprised approximately 25 to 30% of the total subyearling sample from late April through early June, the period fry were observed; this period is about a month earlier than noted in 1986 and 1987. Chinook fry in early May were the dominant proportion (about 85%) of the subyearling sample, though tctal numbers were low. Expanding the fry in the sample to the total collected for the period amounts to only about 10% of the estimate for 1936.

JOHN DAY DAM

In 1988 monitoring activities at John Day Dam were consistent with the 1987 season. No major operational problems occurred.

A new procedure was initiated at John Day Dam this season, that of direct computer entry of brands from smolt captures. With the "valid brand" check program, entry errors are reduced by prompting brand verification while the fish is still in hand.

River flow, Unit 3 discharge, fish passage patterns by species and die1 passage patterns are presented in Appendix C for the 1988 season. The 10 to 90 percent segment of smolt passage by John Day Dam occurred during the following periods:

Chinook yearling	4/24 - 6/ 1
Chinook subyearling	6/22 - 9/ 7
Steelhead	4/26 - 6/ 2
coho	5/ 6 - 5/31
Sockeye	S/12 - 6/ 3

! Retention of the smallest Chinook fry captured is not complete.

Die1 passage patterns (Appendix C, Figures 1 - 45[3]) were consistent with 1987 in that the majority of passage (75-95%) typically occurs during night time hours at John Day Dam (Sims, et al., 1976 and 1981). Reversals of this pattern, though infrequent, do occur. Such a reversal occurred in late August (Appendix C, Figure 21) when about 59 percent of the chinook subyearling passage was during daytime hours.

Chinook fry (subyearling < 60 mm) comprised only about 3% (ca. 3,800) of the total subyearling Chinook sampled during the period fry were observed, early Hay through early June. This amounts to less than 1% of the number of fry observed in 1986 (ca.20,000).

The fish passage index (FPI) and the hydroacoustics index (HI) for John Day Dam for 1988 are presented in Figure 3 for the concurrent sample period; May 13 through August 15 (data from FPDIS). A cursory review of these passage indices indicate that most trends, high and low, are somewhat similar as to date, but the magnitude varies. There was a nearly 6:l increase in 1988 of the HI over the FPI (5.9 million vs. 1.2 million) compared to 1987 when the ratio was about 1:l. Analysis of the hydroacoustics monitoring of juvenile salmonid passage at John Day Dam is being completed by Ouellette (1988).

In consideration of the benefits in fish survival by using a PA system at Lower Granite and McNary Dams, a small scale PA system was incorporated into the fish handling operation at John Day Dam. It was our intent to evaluate the preanesthesia method described by Matthews, et al. (1985) compared to our standard method* in terms of delayed handling mortality, but our evaluation using spring migrants was incomplete. We intend to pursue this next season, 1989.

An attempt to complete a similar evaluation using subyearling chinook was unsuccessful due to very high mortalities even without any handling prior to holding; mortalities after 72 hrs. holding ranged from 12 to nearly 73% (average 41.5%) from late June through July (7 lots, total 725 fish). Most of these fish appeared normal with no physical injury and little or no descaling; water temperatures ranged from 65° to 69' F., not the highest recorded for the summer season. One sample of moribund fish sent for pathological examination revealed systemic Columnaris as the most likely cause of mortality-. one group of later migrants held for delayed mortality (preanesthetized, handled and held for 72 hrs.) showed a mortality of only 4% (N=lOO) while temperatures were near their peak of 71° F. Additional observations

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[1] Die1 passage is shown only for weekly catches >500 per species.

[1] Our standard method was to hand dipnet smolts directly into an anesthetic solution of MS 222.

[j] Courtesy of USFWS, Spring Creek Hatchery.

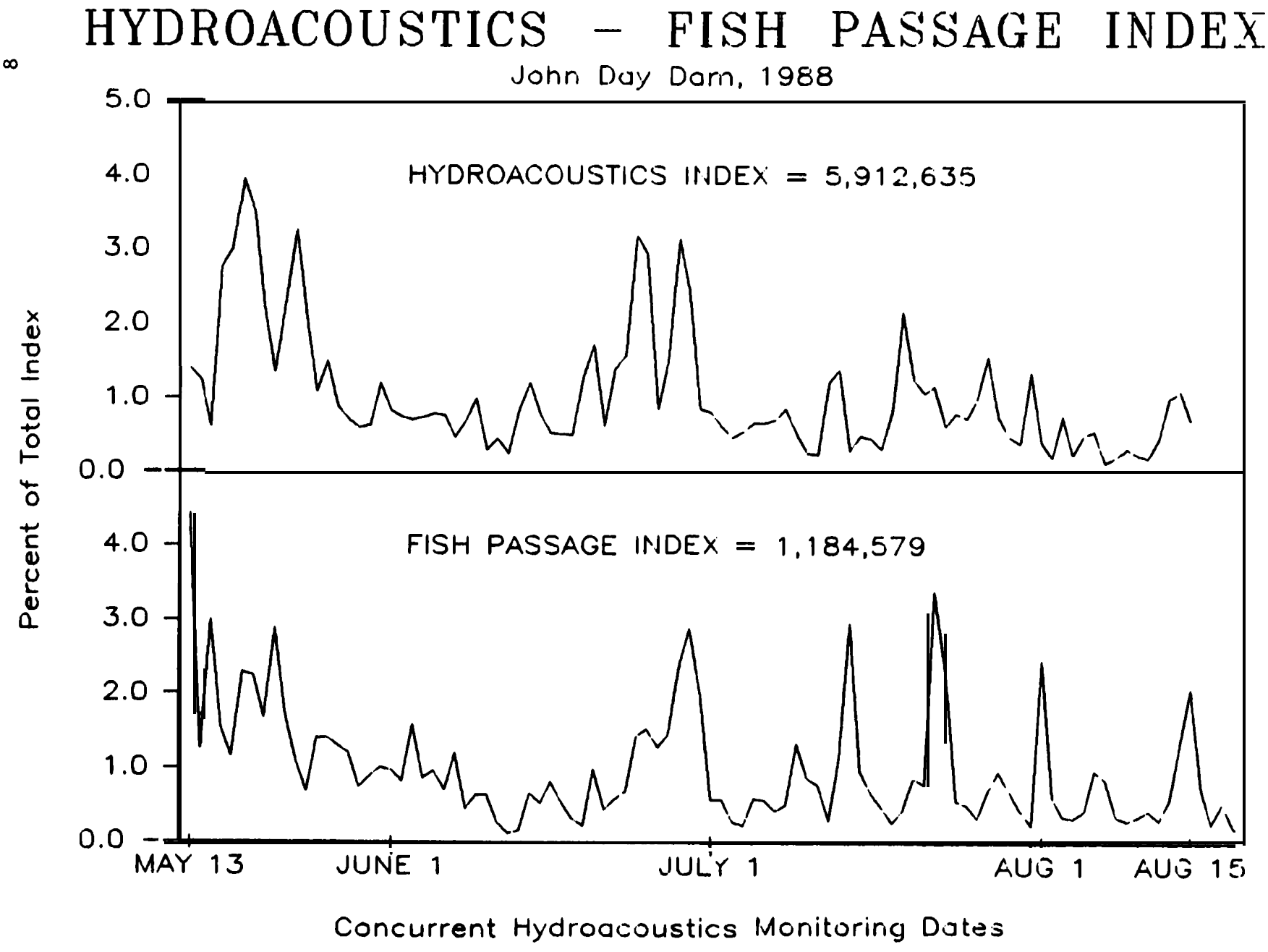

FIGURE 3. Hydroacoustice Index compared with Fish Passage Index during concurrent sampling at John Day Dam, 1988.

are anticipated in future seasons.

Incidental capture of juvenile American Shad is shown in Appendix D, Figure 32. First capture was noted on July 28 and they were present through the sampling season, October 31.

BONNEVILLE DAM

At Bonneville Dam observations of smolt passage in the spring were made from catches in the DSM trap in powerhouse 1 and 2 (DSM 1&2) and gatewell dipnetting of unit 3, gatewell B. Sampling with DSM 1 and 2 continued throughout the season whereas gatewell dipnetting was terminated, as scheduled, on June 30 when it was felt that the DSM 1 sampler would remain reliable.

The DSM 1 sampler was operated from 1600 to 2400, seven days per week. The actual sampling rate varied with fish numbers but was generally set at 15 minutes per hour (25%). The DSM 2 (10% sampler) was normally operated 24 hours a day, seven days per week.

Daily flows for both powerhouses, spill, Unit 9 discharge and daily smolt capture for all three samplers are shown in Appendix D, Figures 1 - 27. Smolt capture pattern is divided into spring (3/15 - 6/30) and summer/fall (7/l - 11/30) components for each DSM. Powerhouse 1 submersible traveling screens were removed from service in the operating units on November 21 and 22, thus decreasing the number of fish diverted into the bypass system after these dates.

During the spring migration, large numbers of hatchery smolts were released into the Bonneville pool. This required temporary interruptions in sampling at DSM 2 and gatewell 9B. The DSM 2 sampler was also out of service at times due to debris plugs, test fish releases, and a DSM video inspection. The DSM 1 sampler operated throughout the entire season, but at a reduced sample duration when large numbers of hatchery smolts were passing PH 1. Notations in Appendix D, Figures 6-10, and 21-27 identify these sampling interuptions or changes from the usual sample day.

Cumulative migrant capture (Appendix D Figure 28 - 30) is shown only for the DSM 1 sampler, the most consistent of the three samplers this year. The PH 1 flow was much more constant than PH 2 which was frequently manipulated for various research activities with the discharge ranging from approximately 5 to almost 50 kcfs.

Dates for the 10 to 90 percent segment of smolt passage by Bonneville Dam PH 1 as measured in DSM 1 are given below:

Chinook yearling - - - - - 4/19 - 5/21
Chinook subyearling - - - - 4/9 - 7/25
Steelhead - - - - - - - - - - 4/26 - 6/2
coho - - - - - - - - - - - - 5/6 - 6/3
Sockeye - - - - - - - - - - 5/14 - 6/2

The subyearling chinook migration was comprised of the progeny of both "tule and "upriver bright" stocks. The spring portion of this migration consists mostly of Bonneville pool hatchery released smolts predominately of "tule" stock. The summer/fall segment of the subyearing migration consists mostly of "upriver bright" smolts. Species composition of the spring migration for the three samplers (Figure 4) was generally similar, however, some difference occurred between DSM 1 and 2 samplers, particularly between yearling and subyearling chinook. The DSM 1 sampler total capture percentage was lower for yearling and higher fcr subyearling chinook than the DSM 2 sampler.

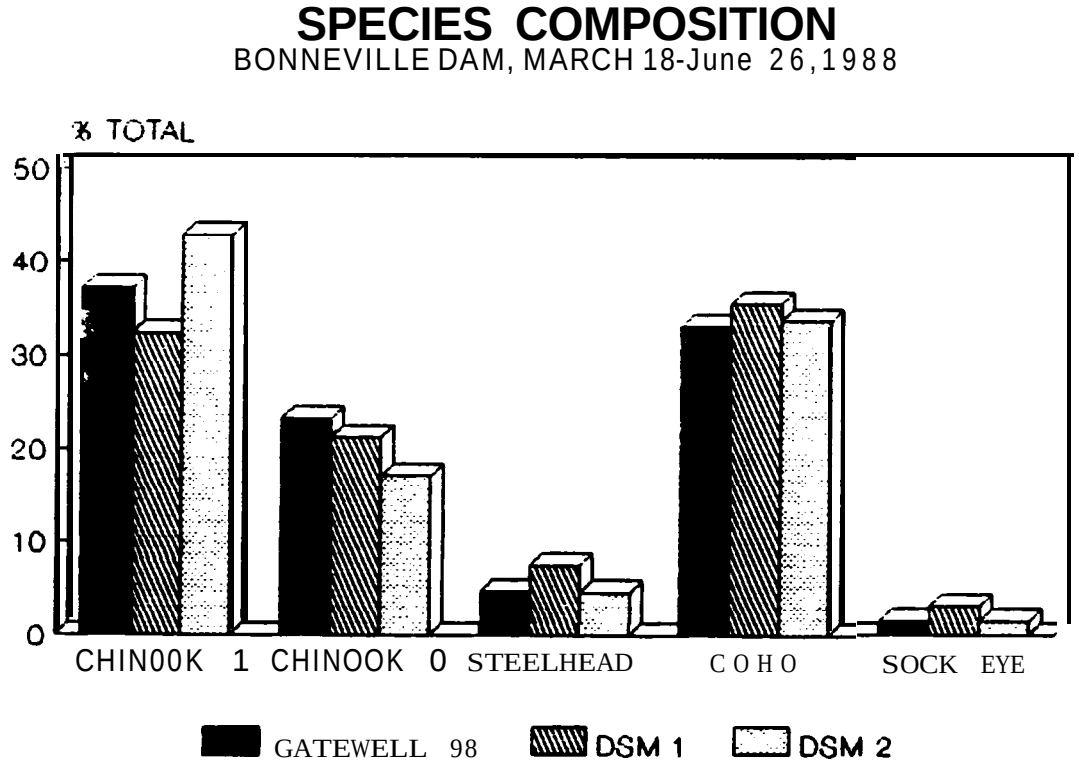

FIGURE 4. Species composition of catches from dipnetting Gatewell 9B and Downstream Migrant (DSM) trap captures from the bypass in Powerhouse 1 and 2 at Bonneville Dam.

Smolt descaling observed in 1988 catches from dipnetting gatewell 9B and from DSM 1 and 2 are listed below with similar observations in 1987 by Gessel, et al. (1988) for DSM 1 and 2:

Year	Yrlin Chin.	SubYrlng Chin.	Steelhead	Coho	Sockeye
1987					
DSM 1	3.7%	4.1%	4.1%	3.2%	25.5%
DSM 2	5.7%	2.6%	3.8%	4.8%	21.1%
1988					
DN(9B)	3.3%	1.5%	6.6%	2.7%	17.2%
DSM 1	4.4%	1.7%	6.1%	3.3%	23.5%
DSM 2	4.6%	2.2%	7.6%	3.4%	13.8%

For each sampling method and both years, sockeye smolts fared the worst as has also been documented at McNary Dam for 1985 - 87 (Koski, et al., 1988) as well as in 1988 Knapp and Wagner, 1988).

Incidental catches in DSM 1 included two chum salmon smolts in early May and 8200 adult euiachon were noted in samples from April 17 to 24. Taking into account the hourly sample rate, this suggests a fallback passage of about 95,500 eulachon through the bypass system. The sex ratio and length of 100 random eulachon fish on April 17 was found to be 30% female with an average fork length of 182mm compared to 70% male composition averaging 191mm. Juvenile American shad began appearing in the samplers by early September. Capture frequency was sporadic and low until late October and November when numbers rose dramatically (Appendix D, Figure 31). For comparison, juvenile shad incidence at John Day Dam is also shown in Appendix D Figure 32.

SUMMARY

The 1988 smolt monitoring project of the National Marine Fisheries Service provided data on the seaward migration of juvenile salmon and steelhead at Lower Granite, Mcnary, John Day, and Bonneville Dams. All pertinent fish capture and condition data as well as dam operations and river flow data were provided to the FPDIS for use by FPC in developing fish passage indices and migration timing, and for water budget and spill management.

◊ Data through 6/30 except subyearling chinook through 11/30.

A C K N O W L E D G M E N T S

Support for this smolt monitoring project comes from the region's electrical ratepayers through the Bonneville PowerAdministration.

The success of this program continues to involve cooperative interaction with the Northwest and Alaska Fisheries Center, Coastal Zone and Estuarine Studies Division in both personnel and facilities of the Pasco and North Bonneville Field Stations. It is appreciated.

On-site biologists, assistants and others of the Corps of Engineers provided valuable guidance and assistance at each sampling site: Lower Granite, McNary, John Day and Bonneville Dams.

We acknowledge the very capable efforts of our biologists, technicians, maintenance and contract persons; their work was vital. Key people were Gary Lambacker, Lee Ferguson, Randy Absolon Susan Cielinski, and Dave Jepsen. We also acknowledge the especially helpful co-manager, Diane Sheffield, of the Washington department of Wildlife at Lower Granite Dam.

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APPENDIX A
LGWER GRANITE DAM - 1388

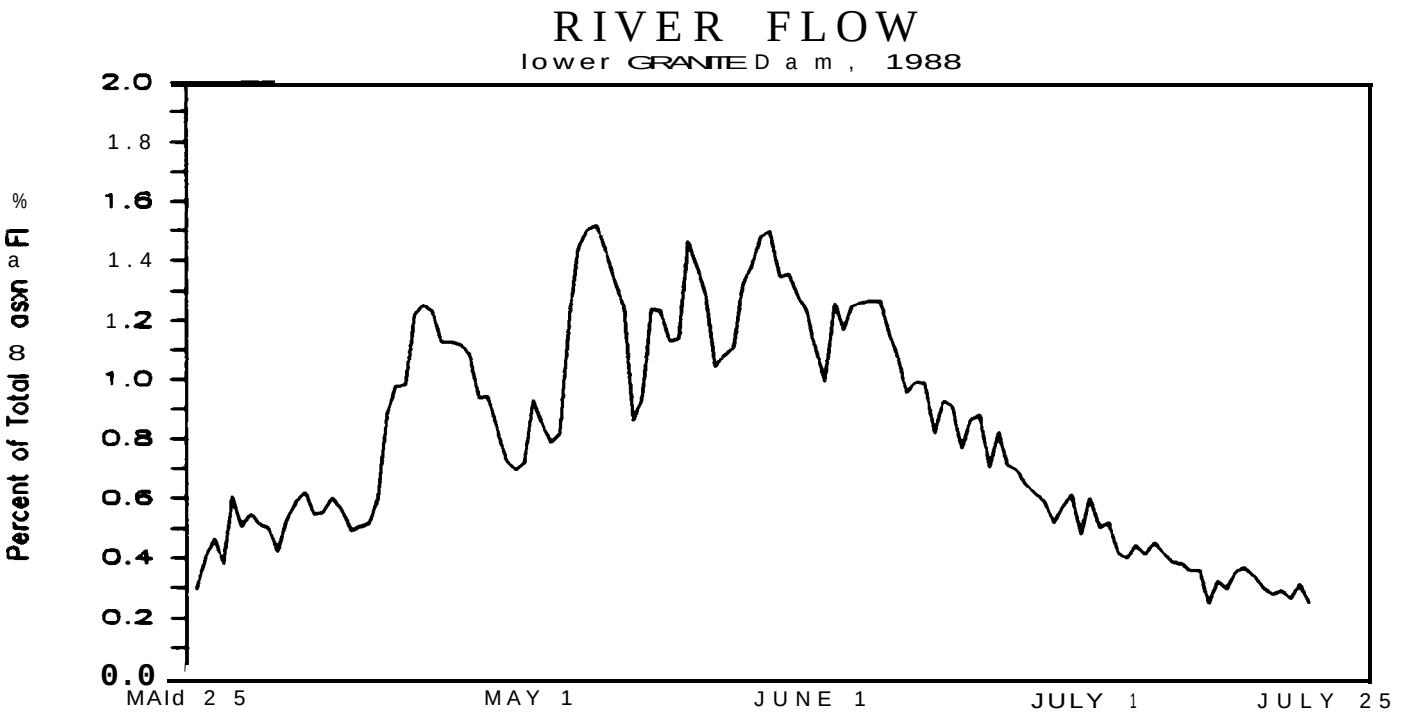


FIGURE1

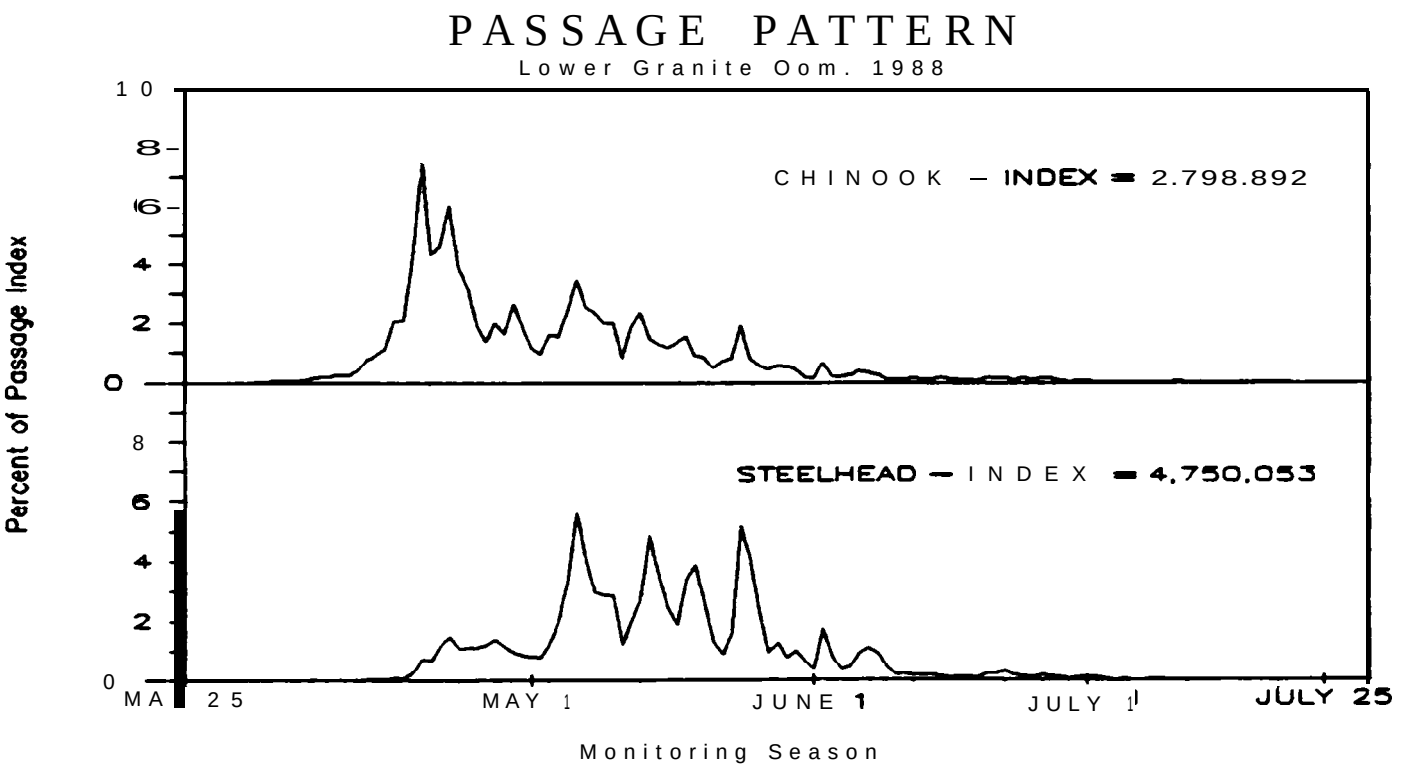
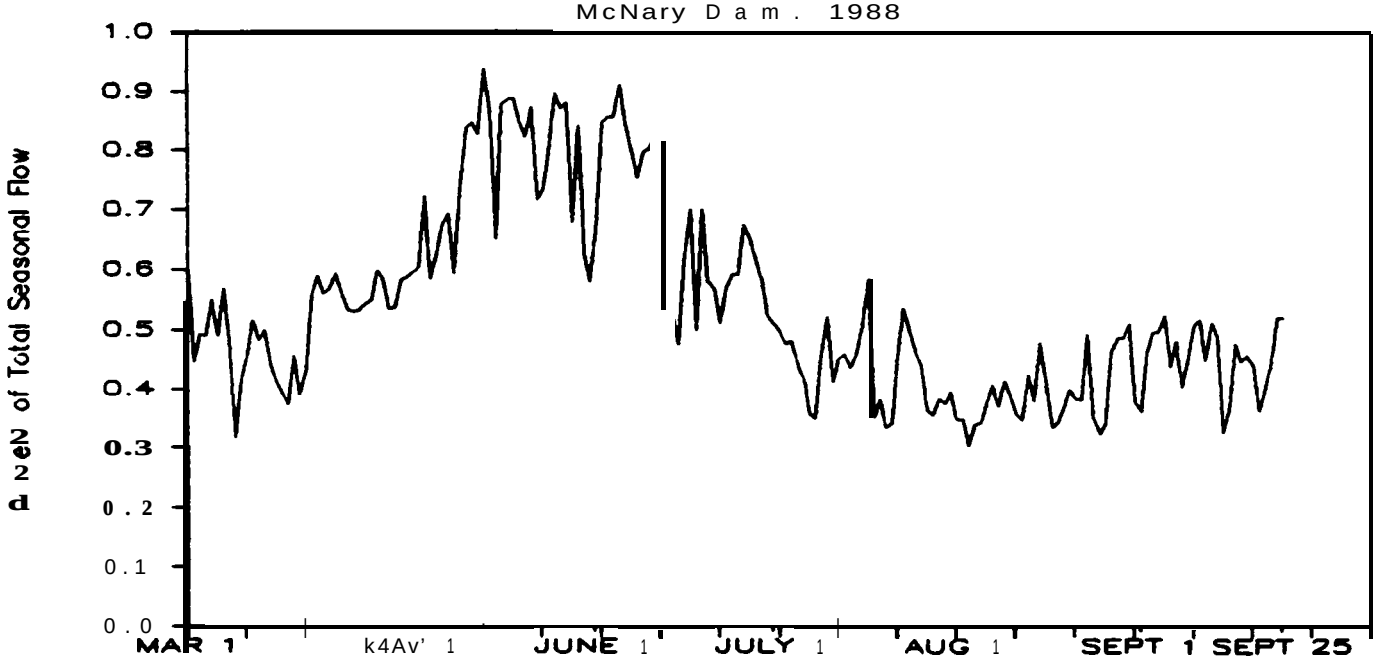


FIGURE 2

APPENDIX B
McNARY DAM - 1088

RIVER FLOW

McNary Dam. 1988

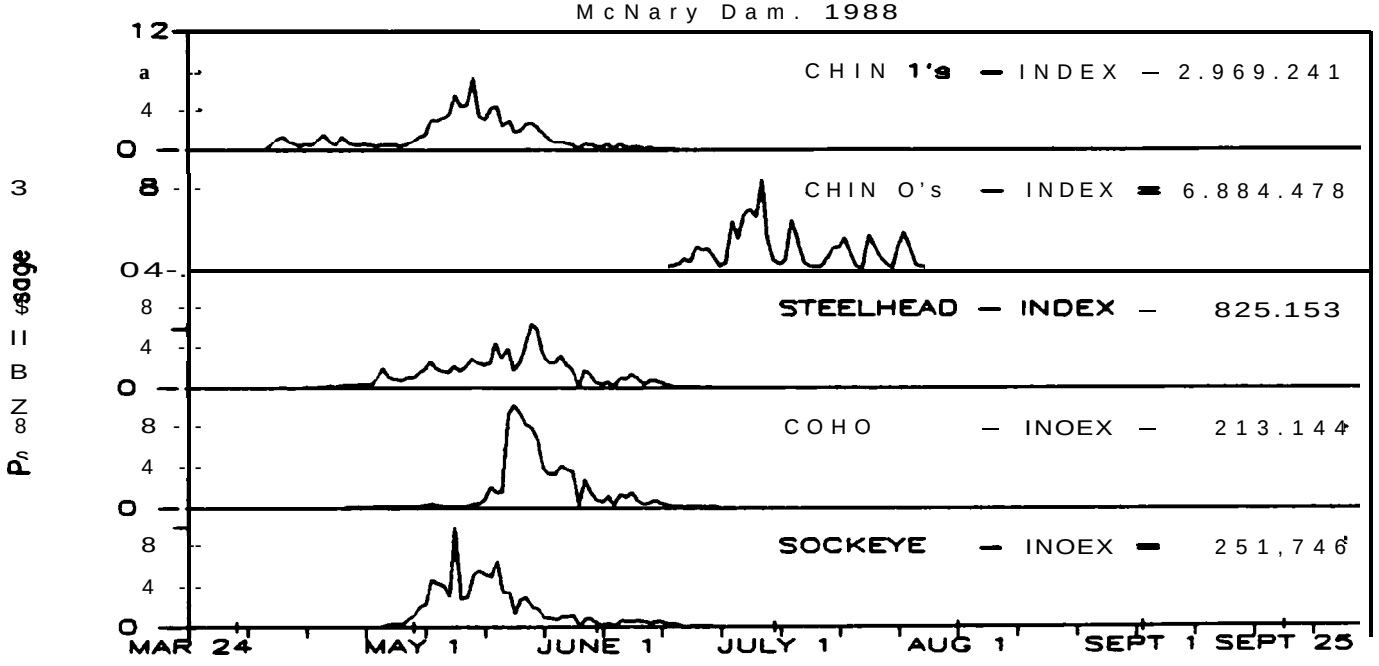


Monitoring Season

FIGURE 1

PASSAGE PATTERN

McNary Dam. 1988



Monitoring Soaoon

FIGURE 2

APPENDIX C
JOHN DAY DAM - 1988

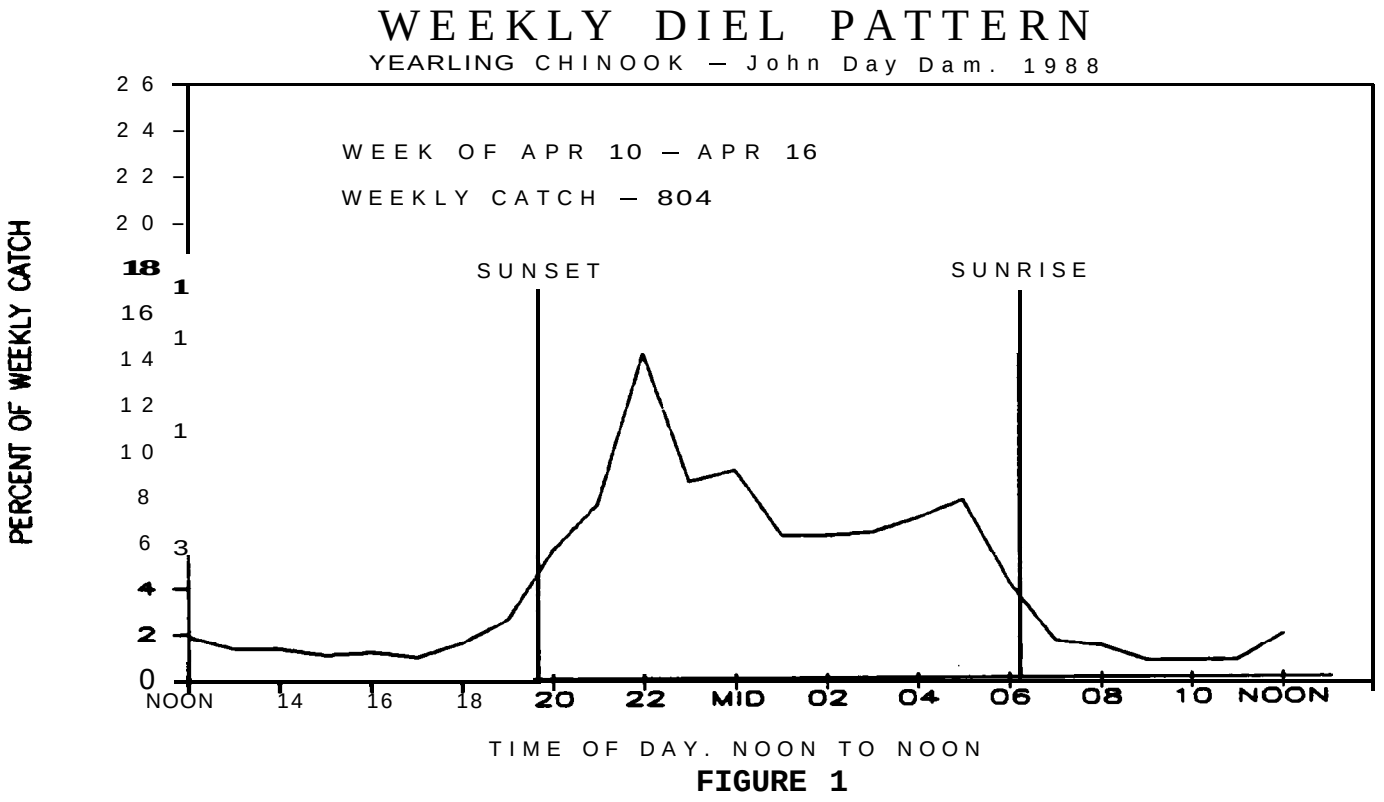


FIGURE 1

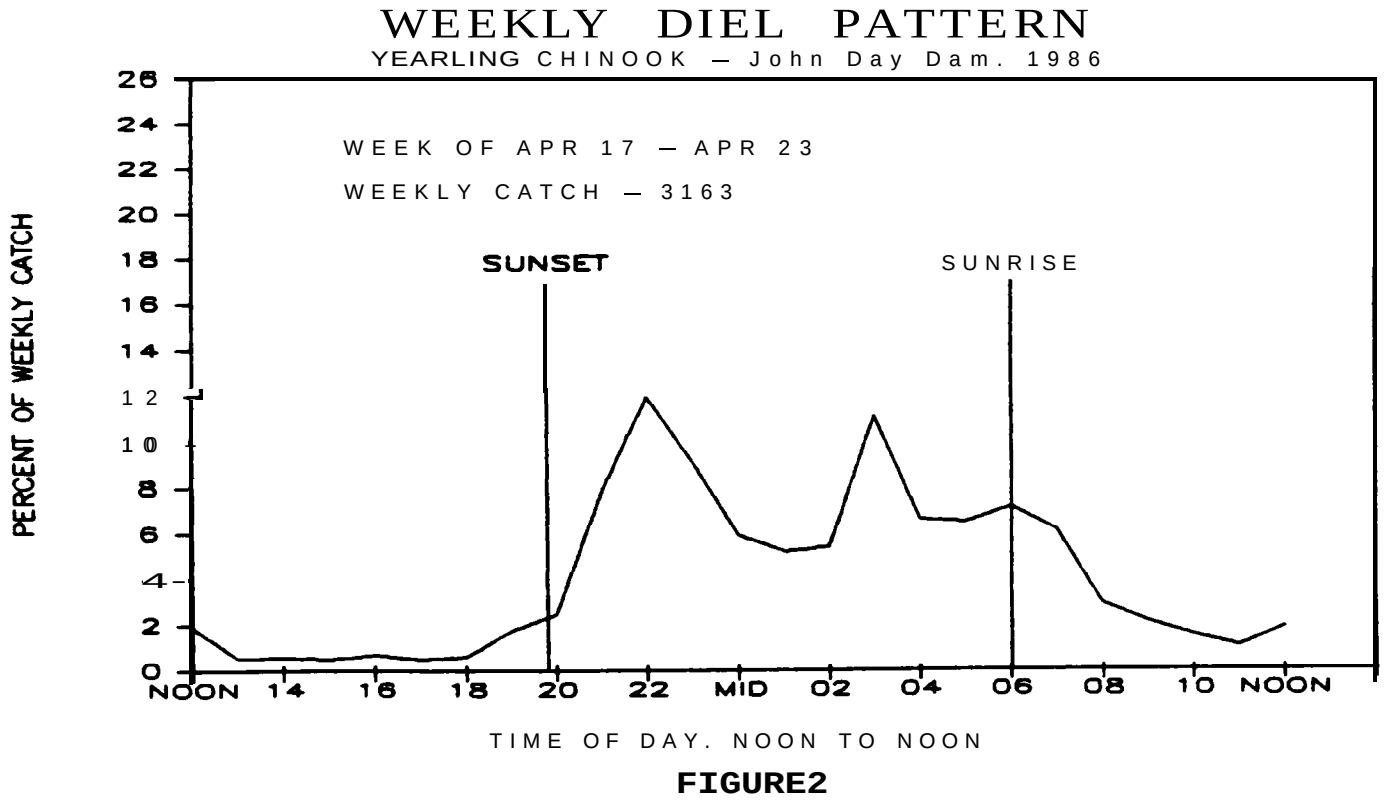
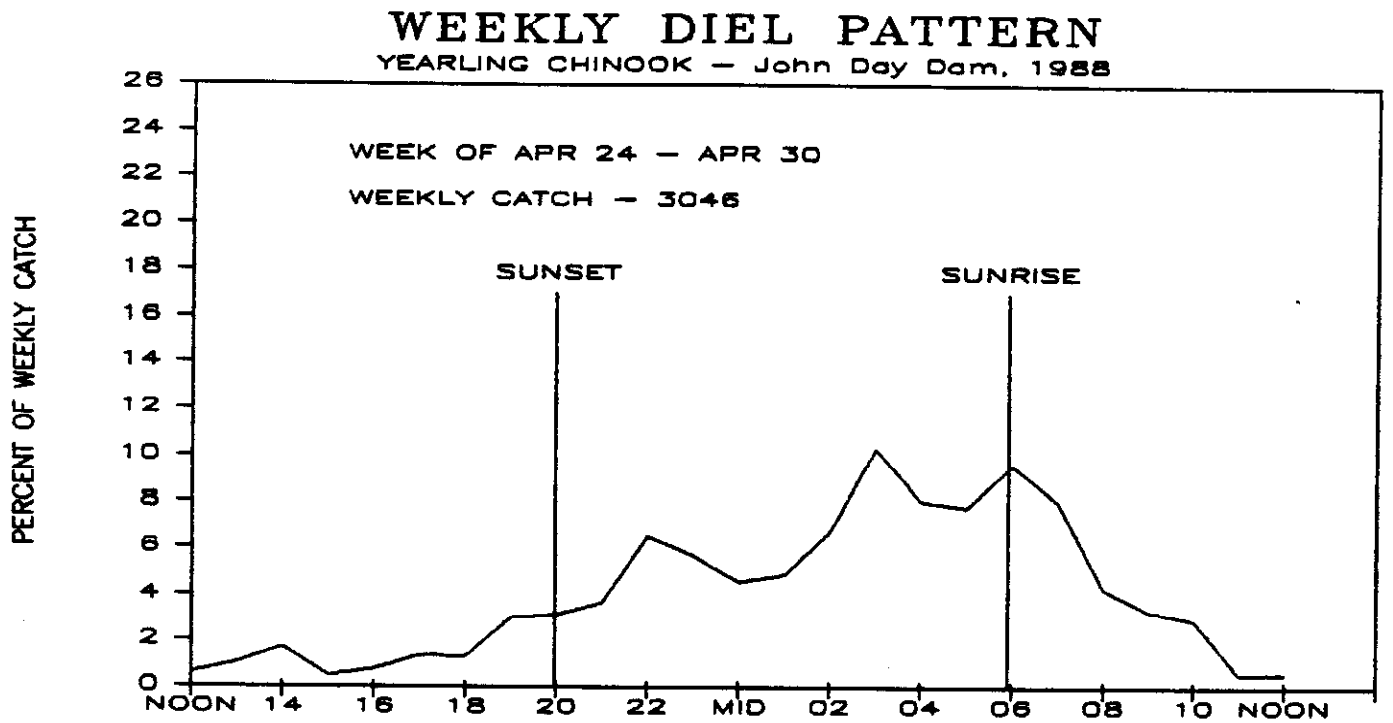


FIGURE2



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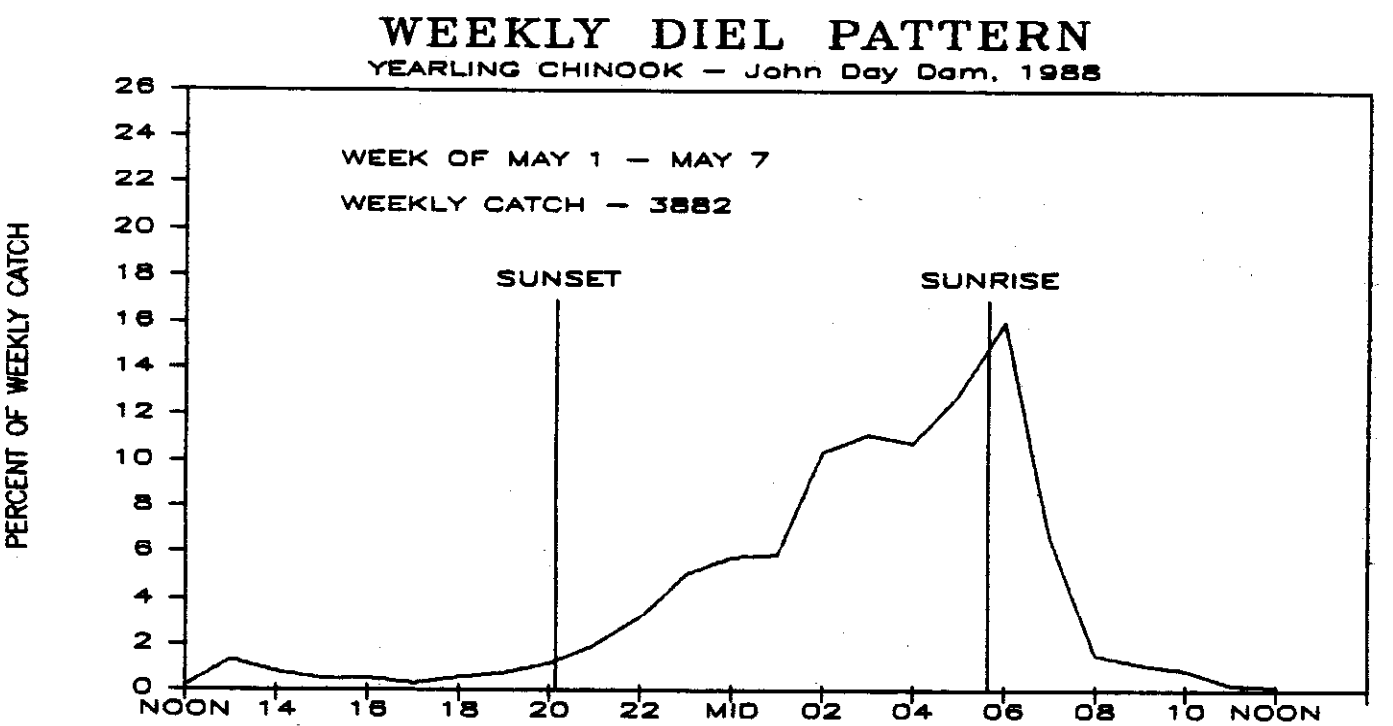

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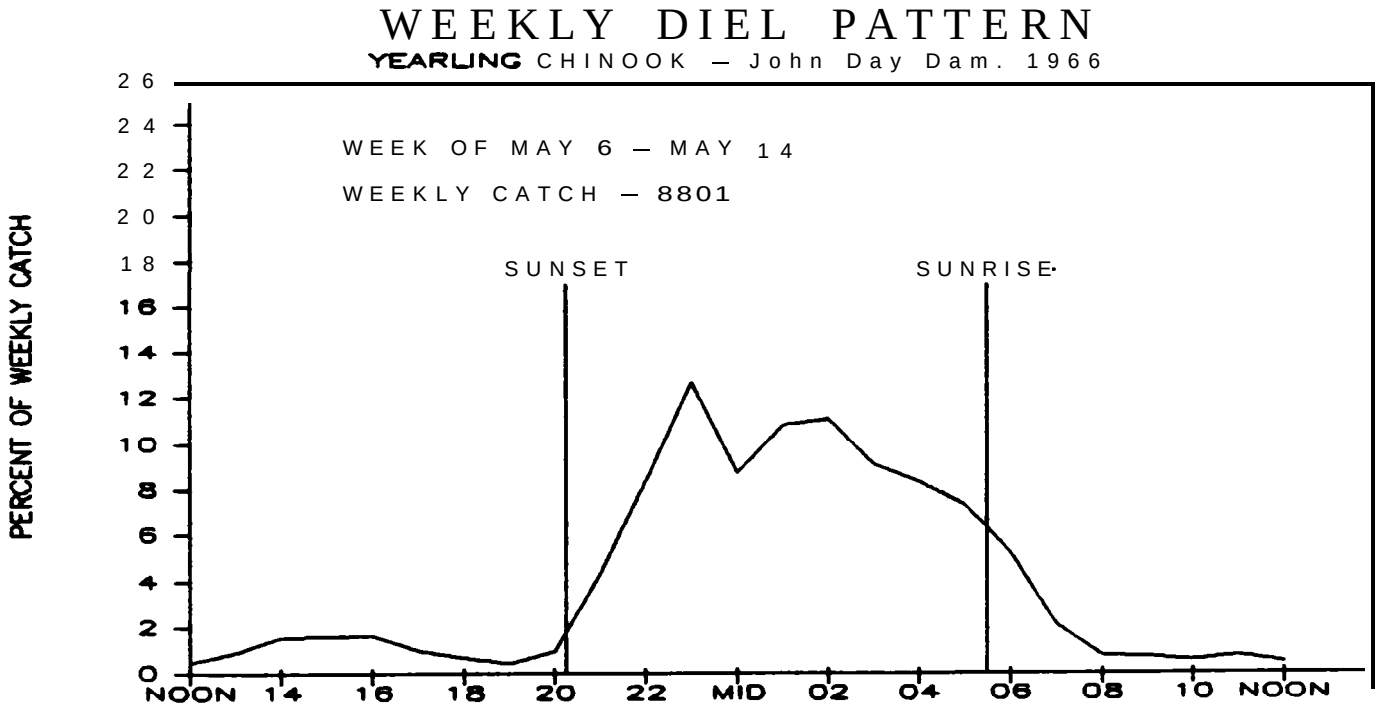

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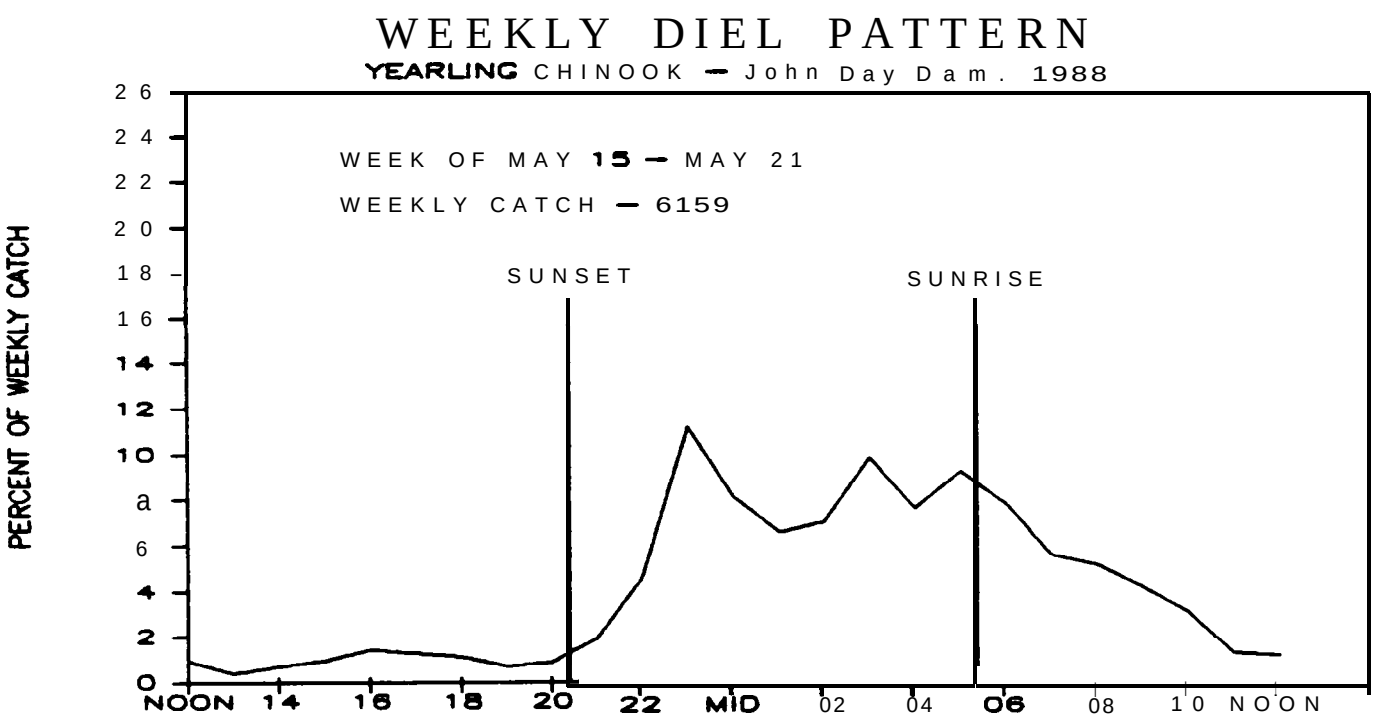

FIGURE 6

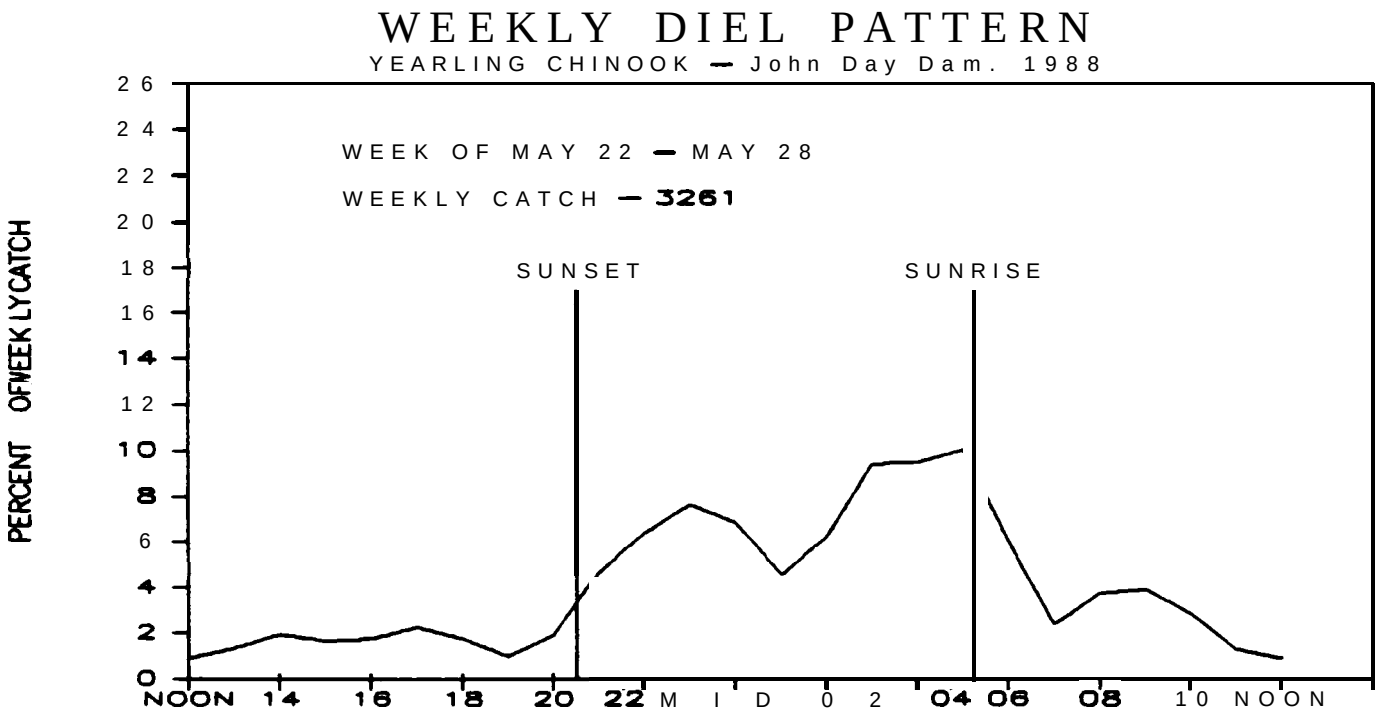

FIGURE 7

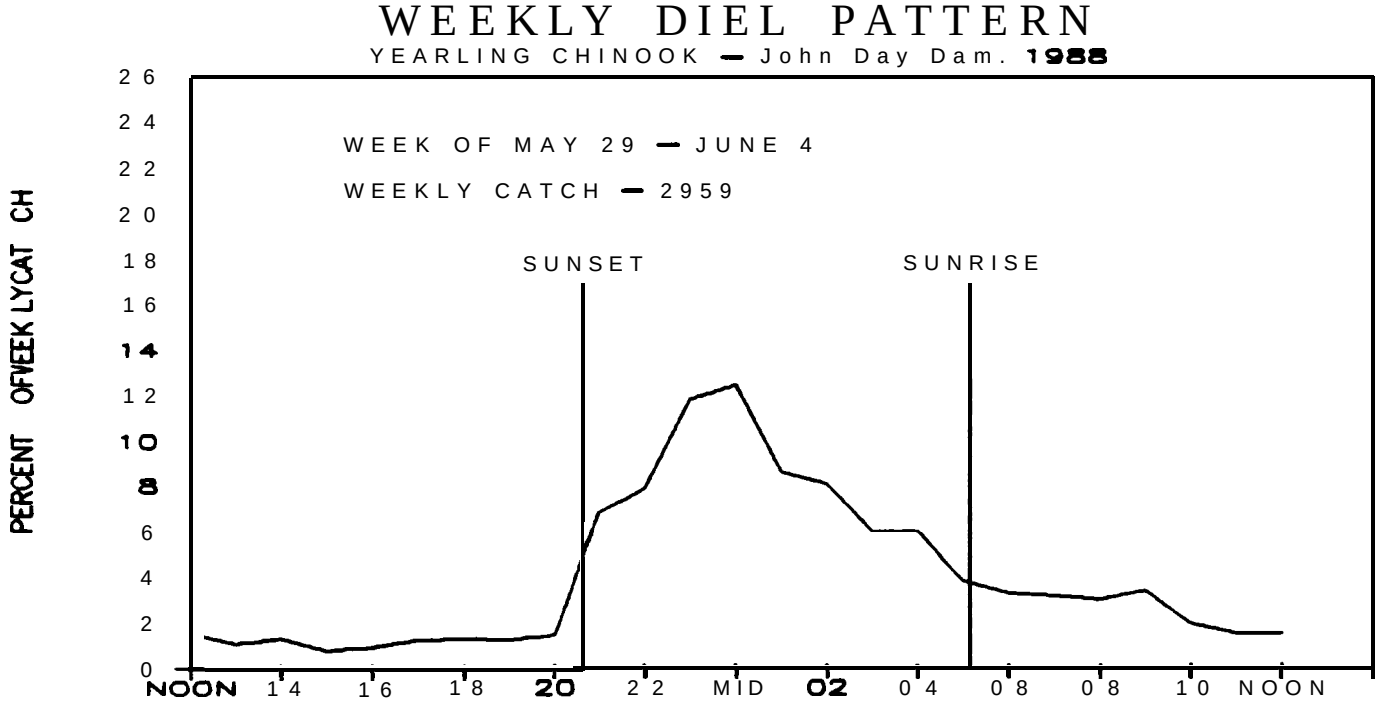

FIGURE 8

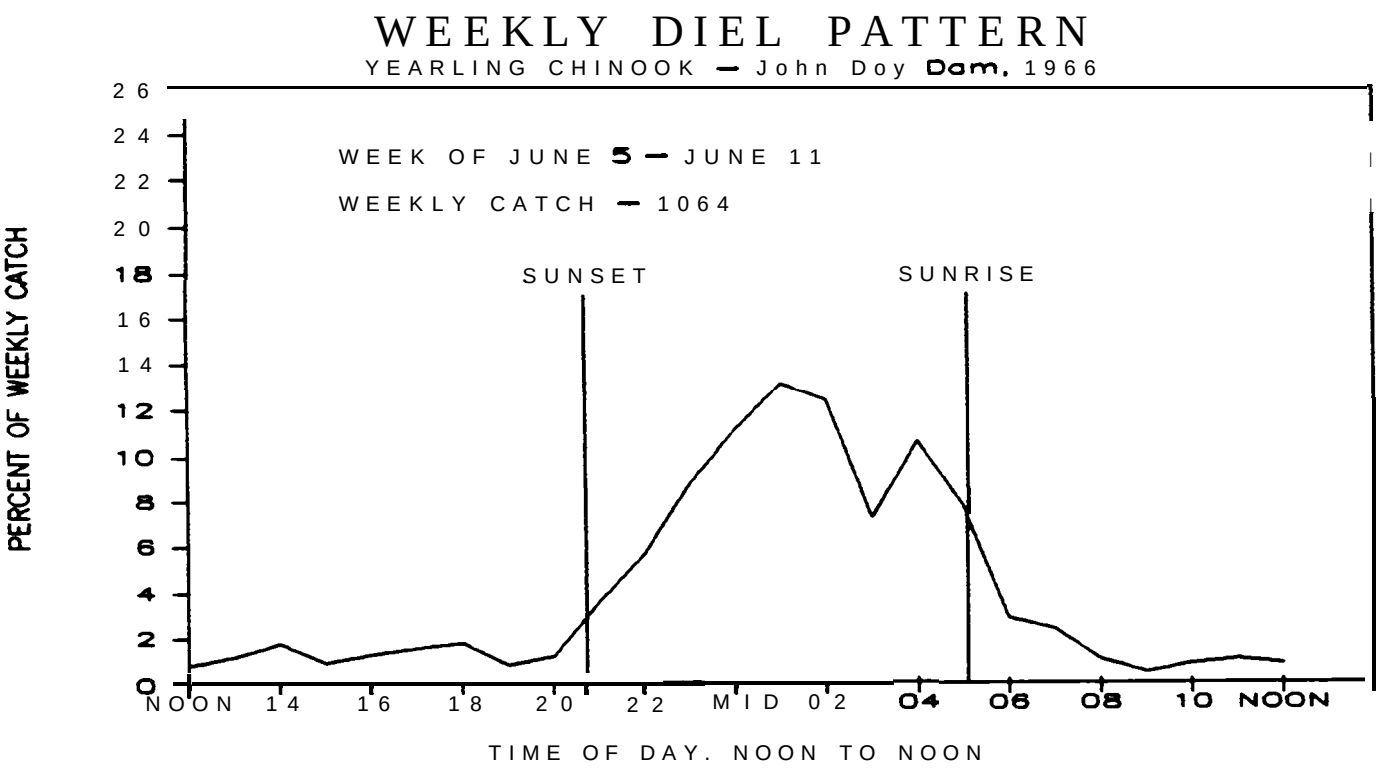
WEEKLY DIEL PATTERN
YEARLING CHINOOK — John Doy Dam, 1966
WEEK OF JUNE 5 — JUNE 11
WEEKLY CATCH — 1064
SUNSET
SUNRISE
PERCENT OF WEEKLY CATCH
26
24
22
20
18
16
14
12
10
8
6
4
2
0
NOON 14 16 18 20 22 MID 02 04 06 08 10 NOON
TIME OF DAY. NOON TO NOON

FIGURE 9

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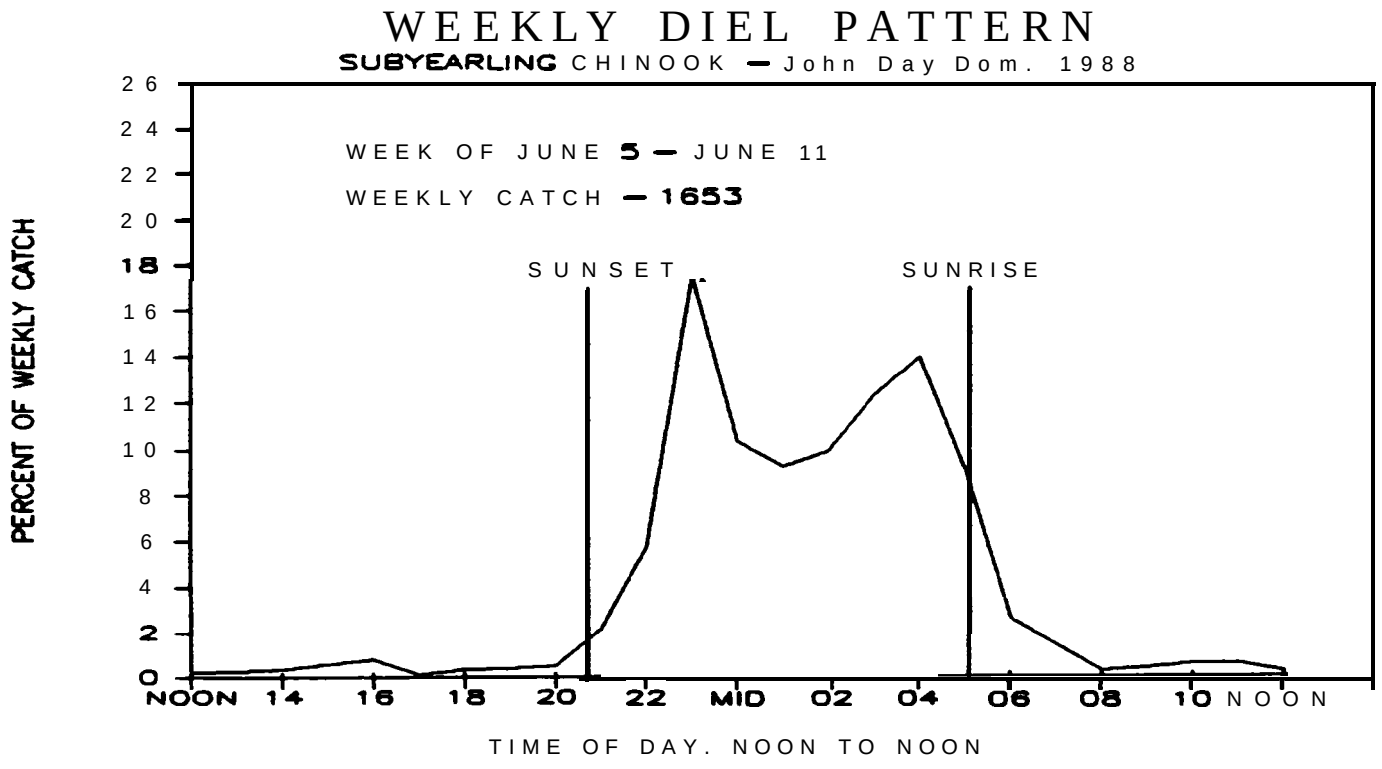

FIGURE 10

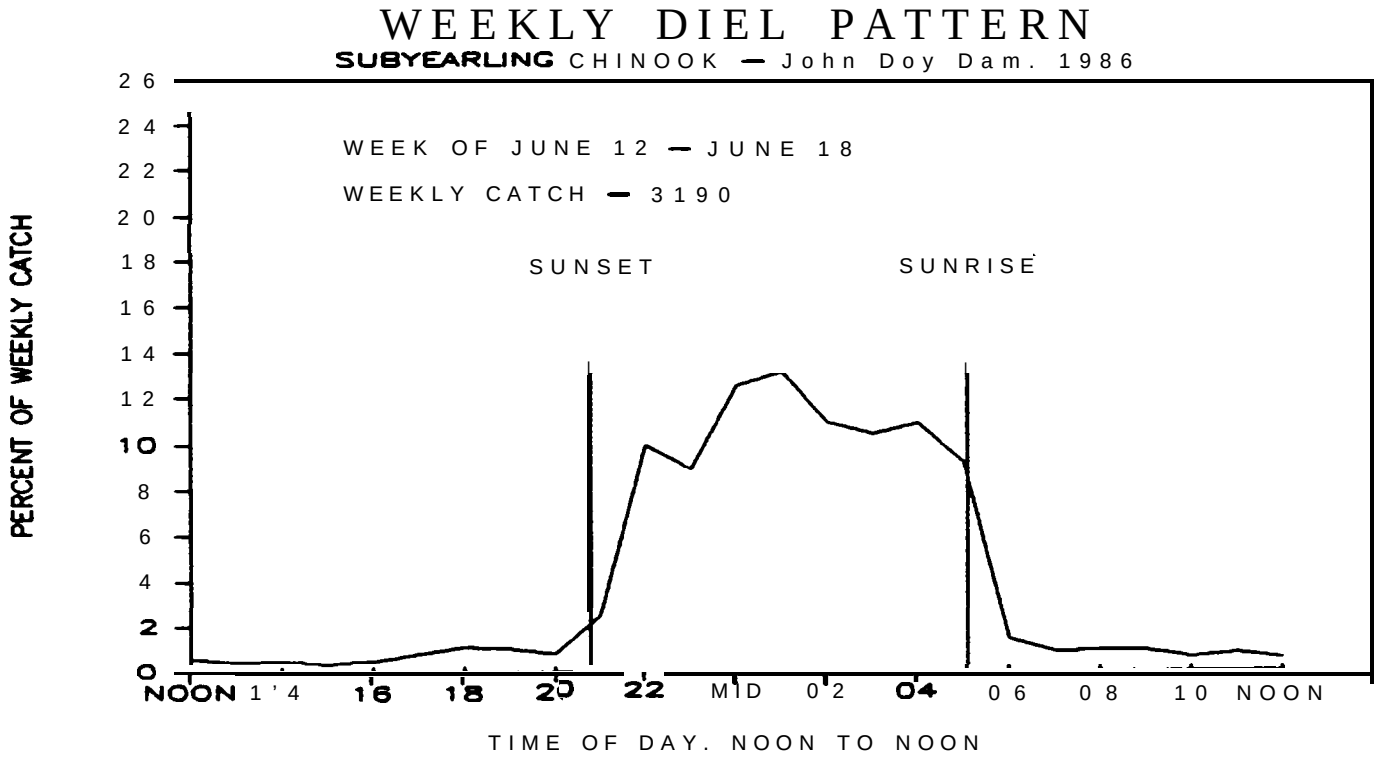

FIGURE 11

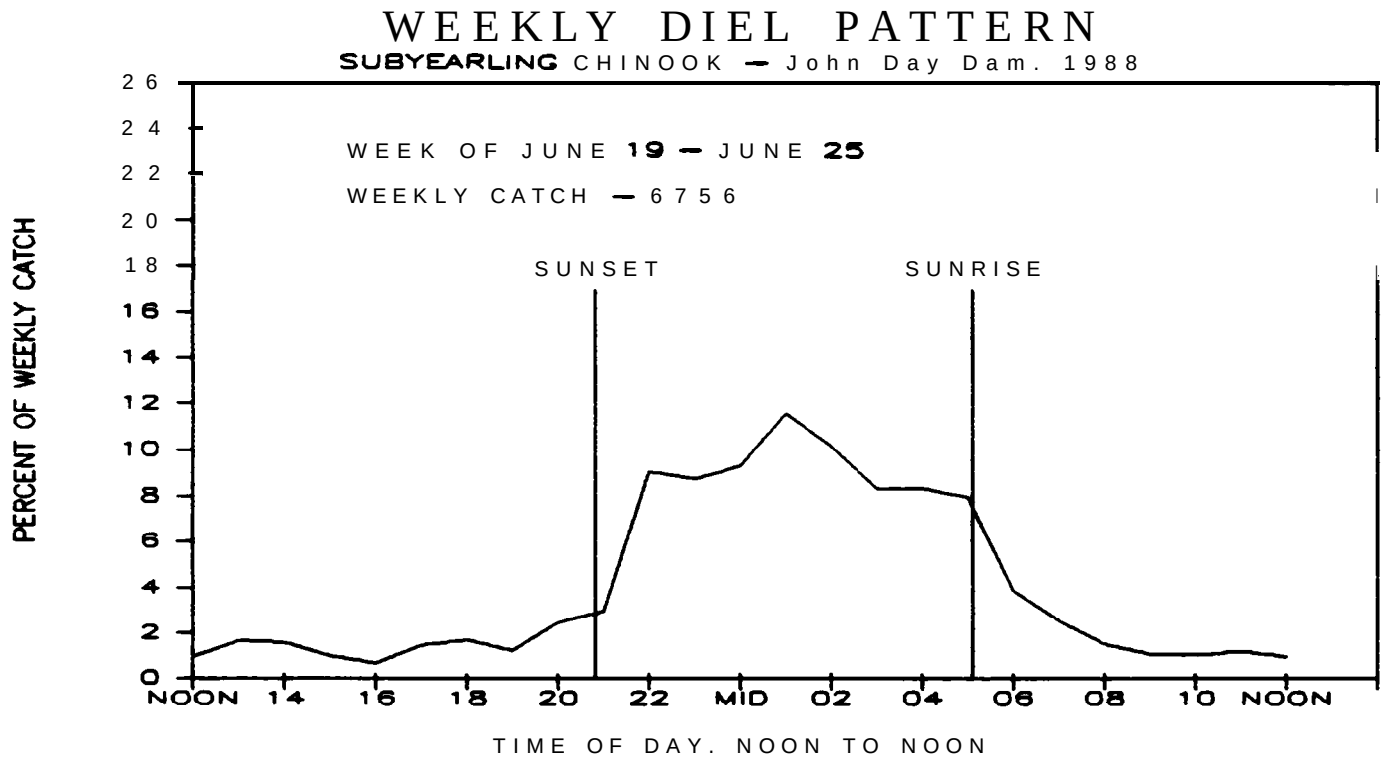

FIGURE 12

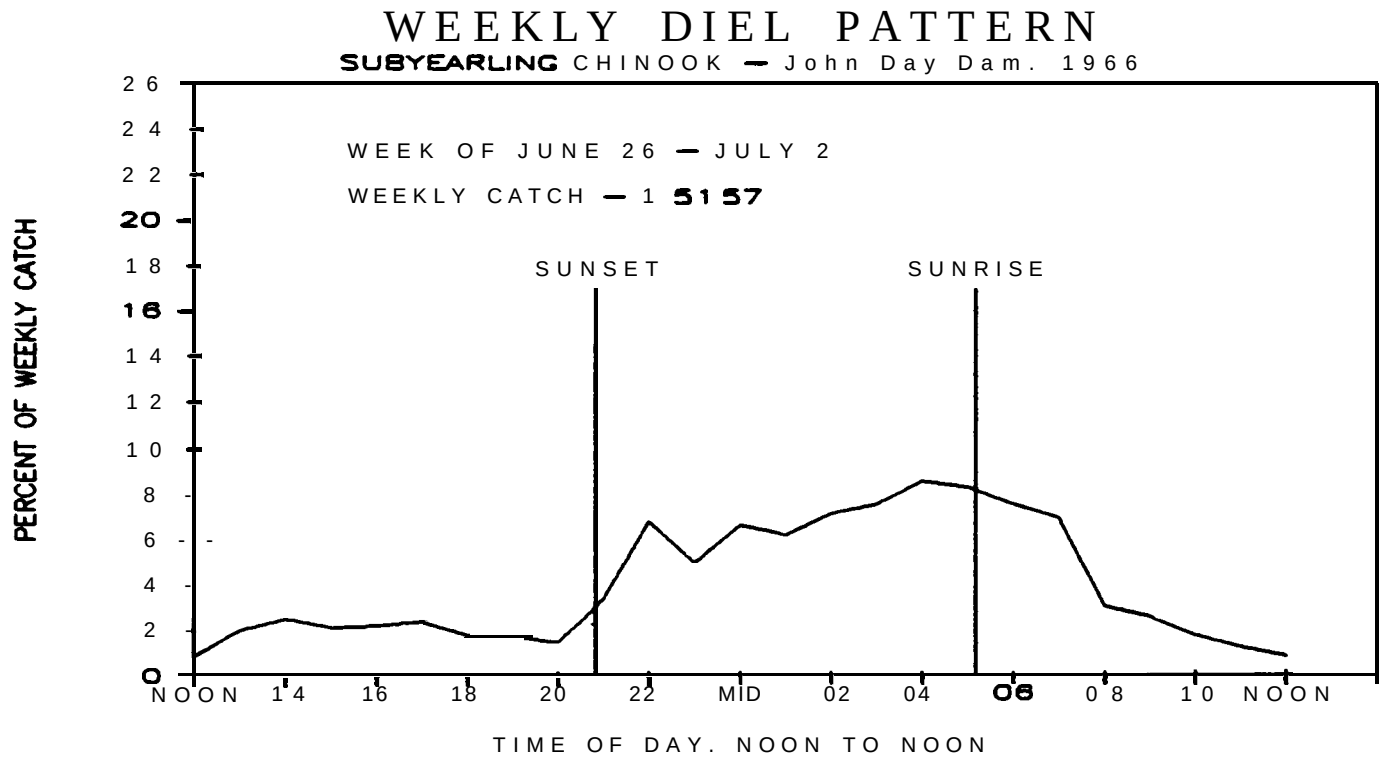

FIGURE 13

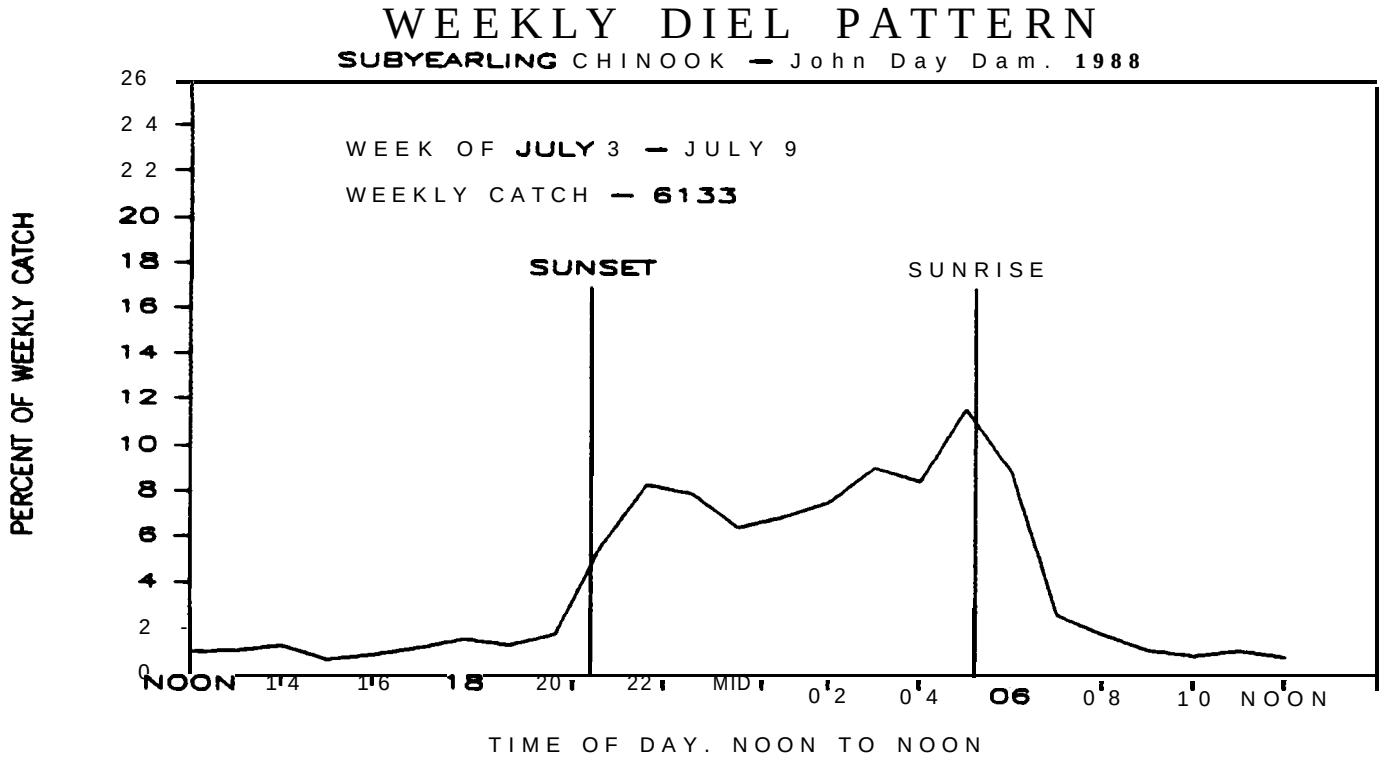

FIGURE 14

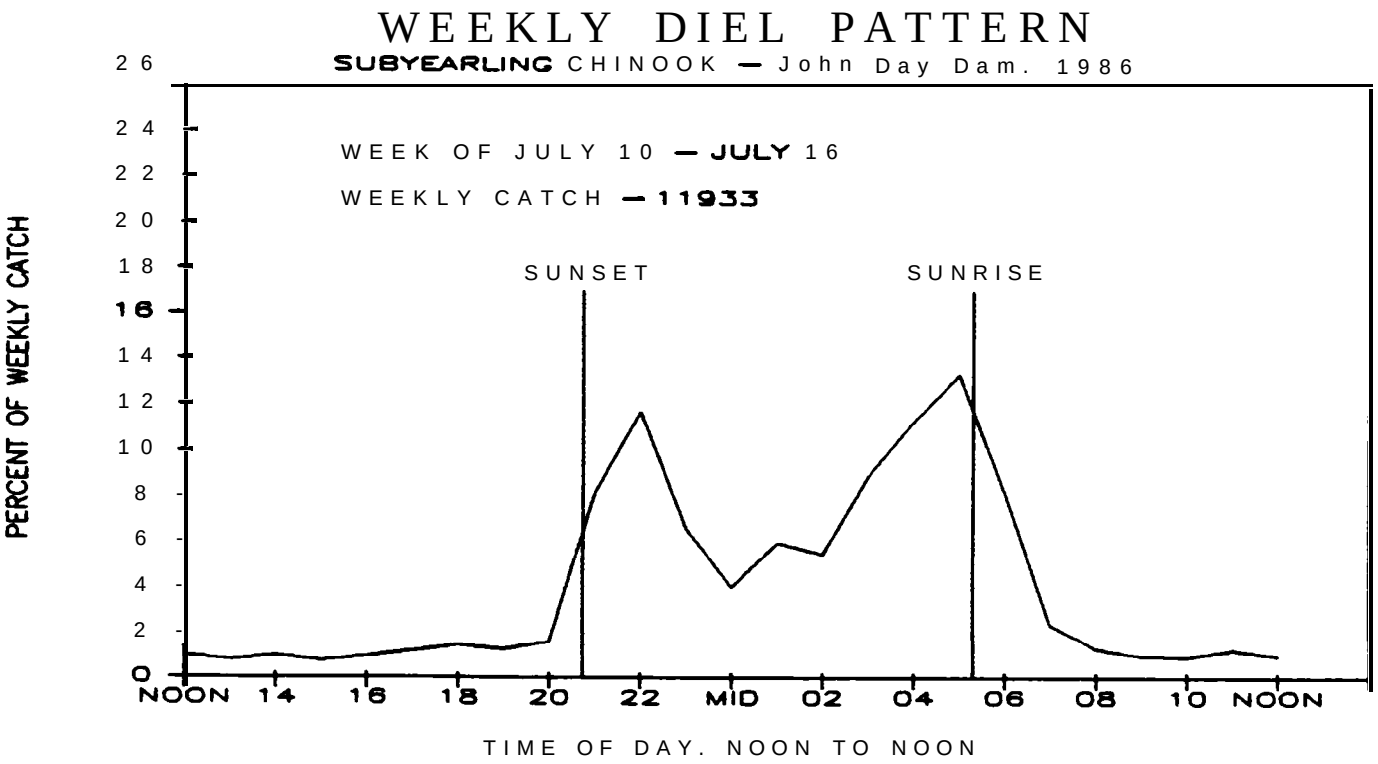

FIGURE 15

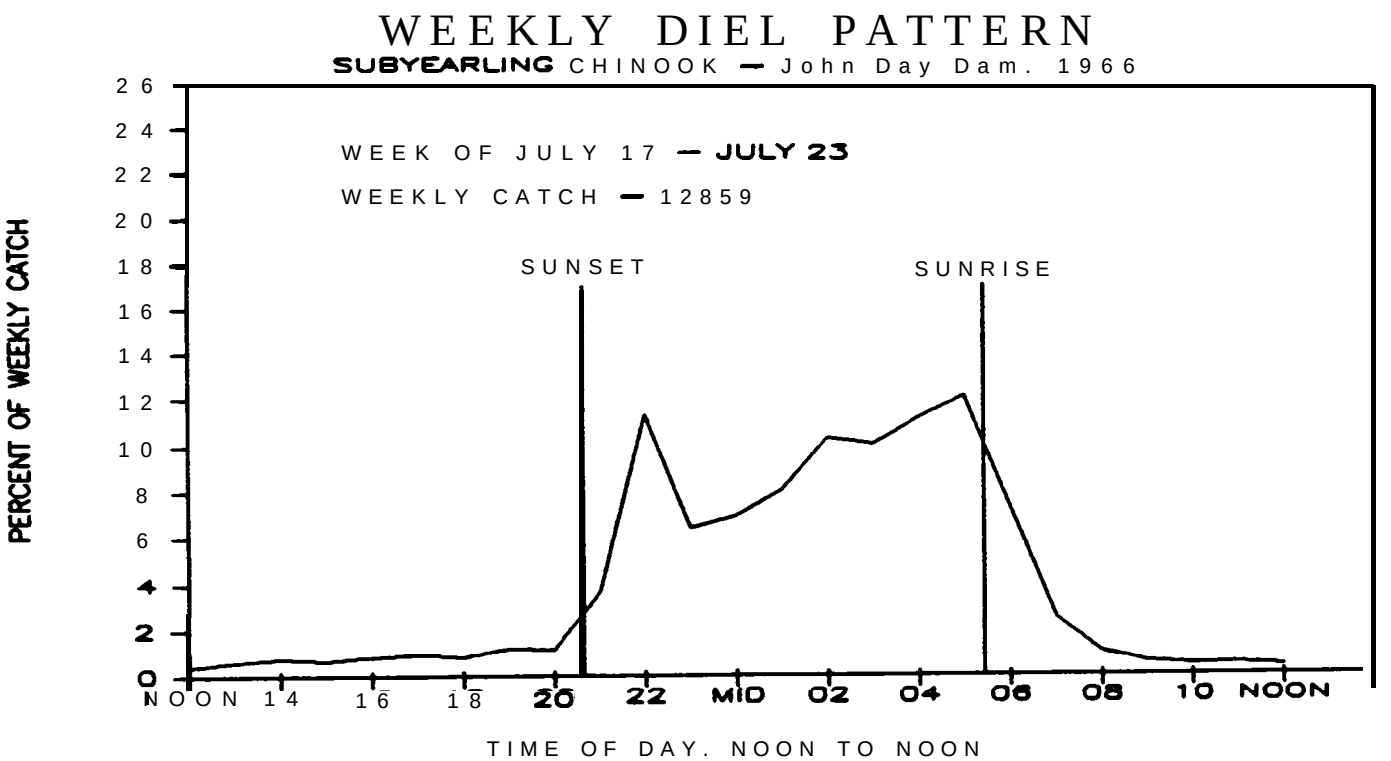

FIGURE 16

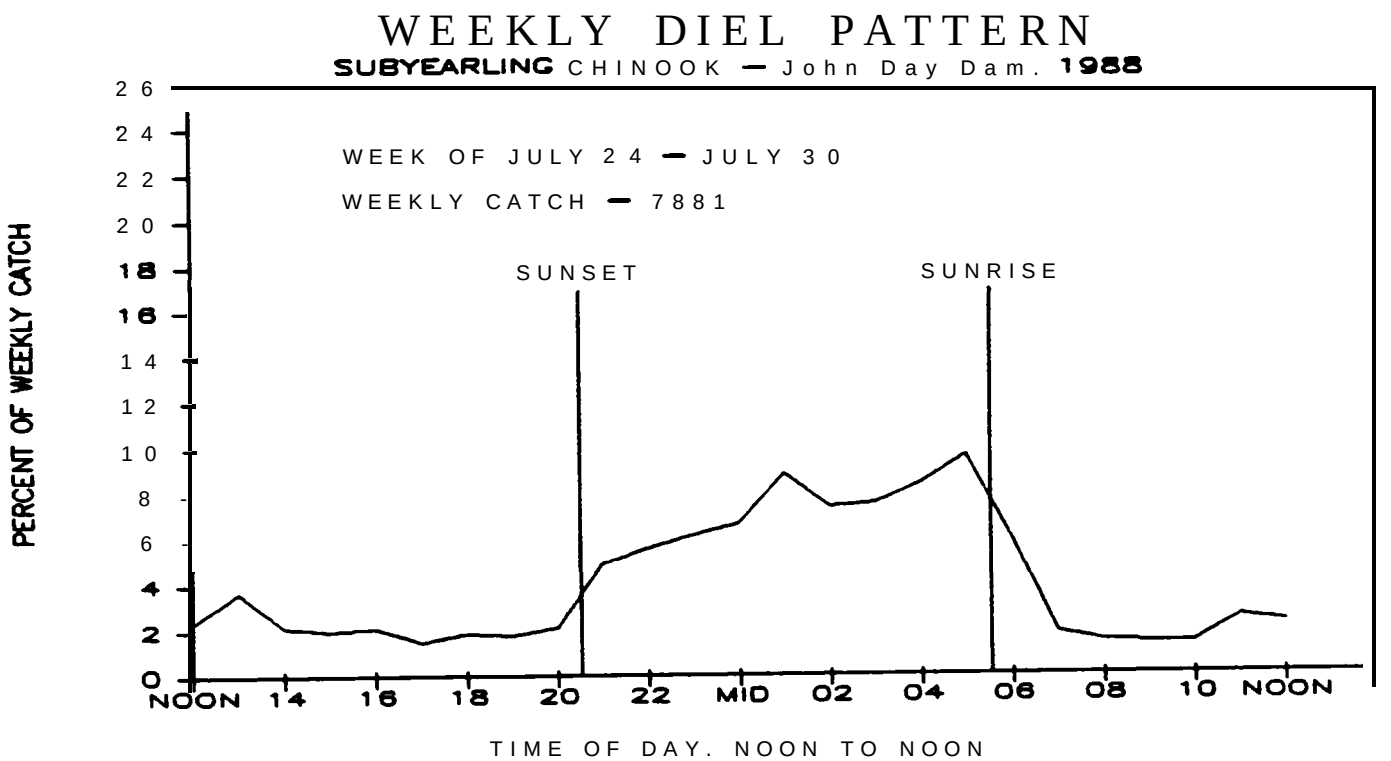

FIGURE 17

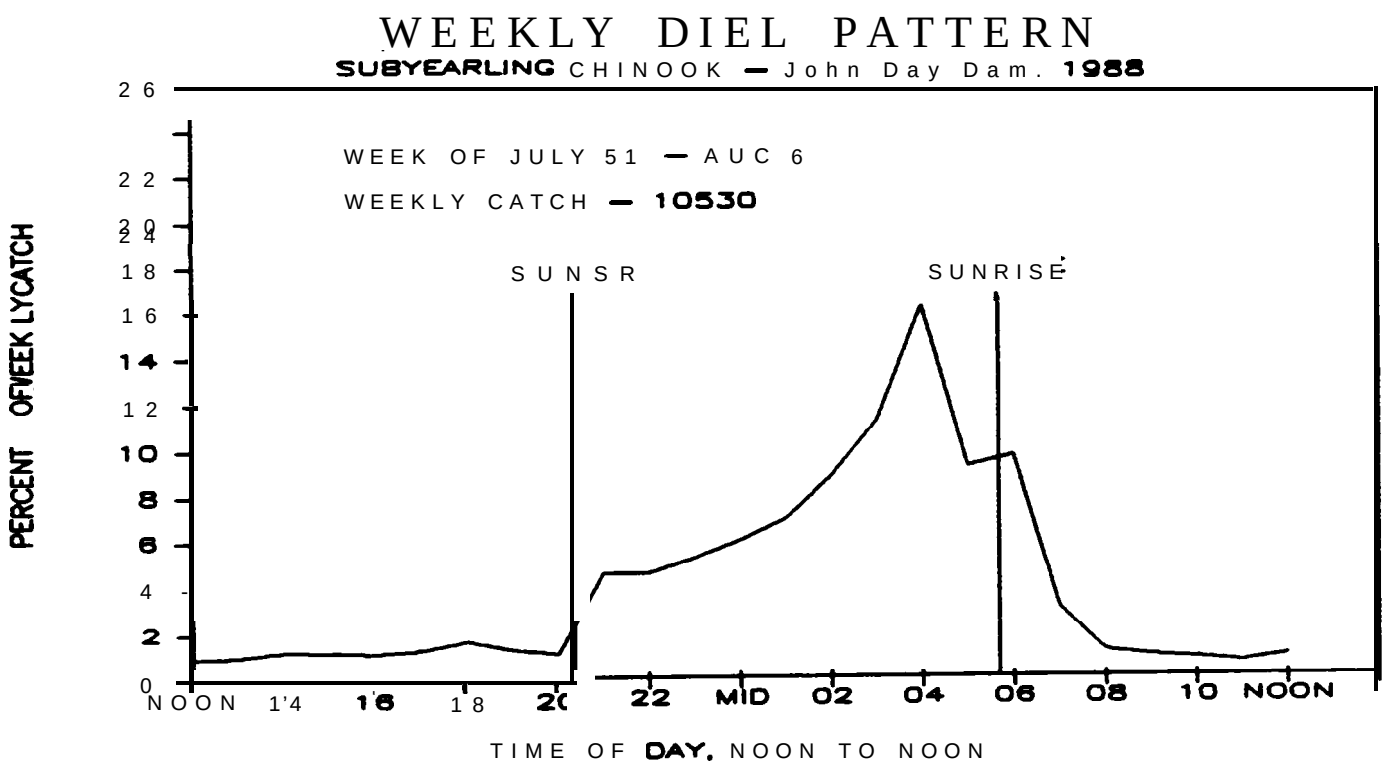

FIGURE 18

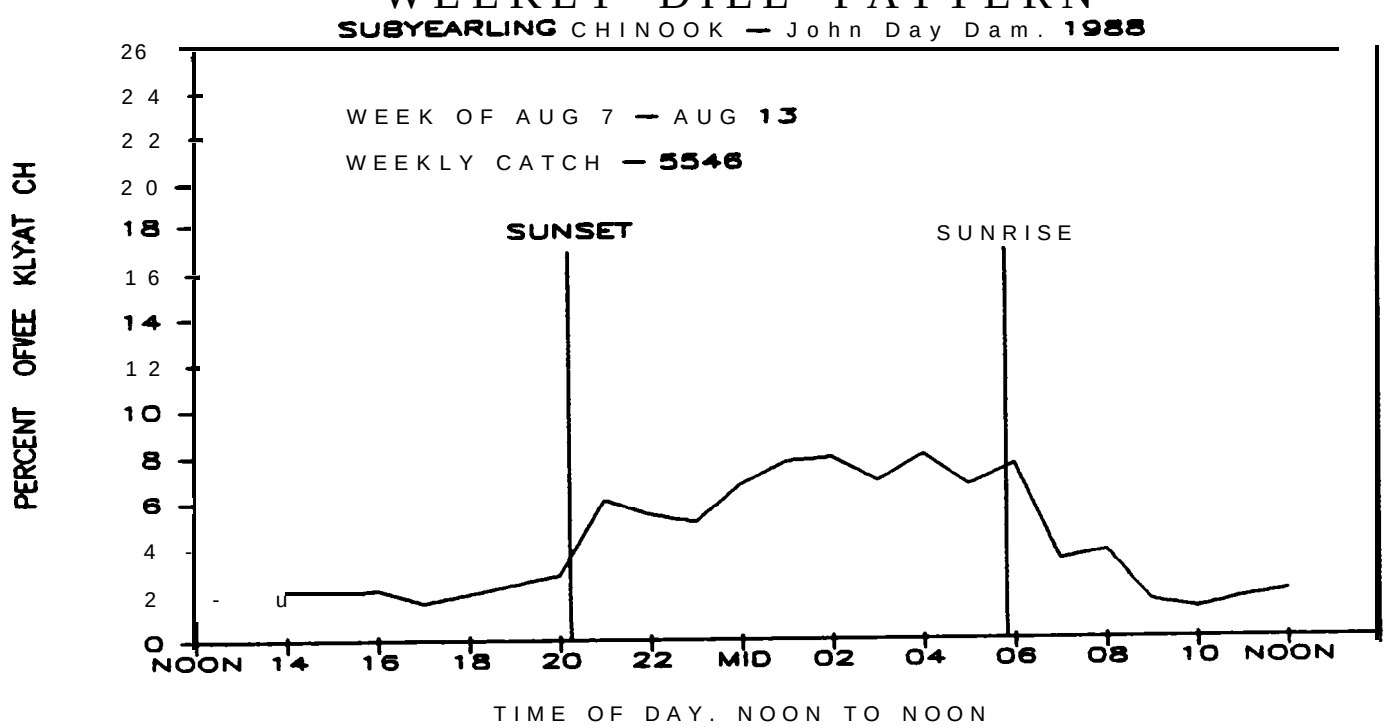

FIGURE 19

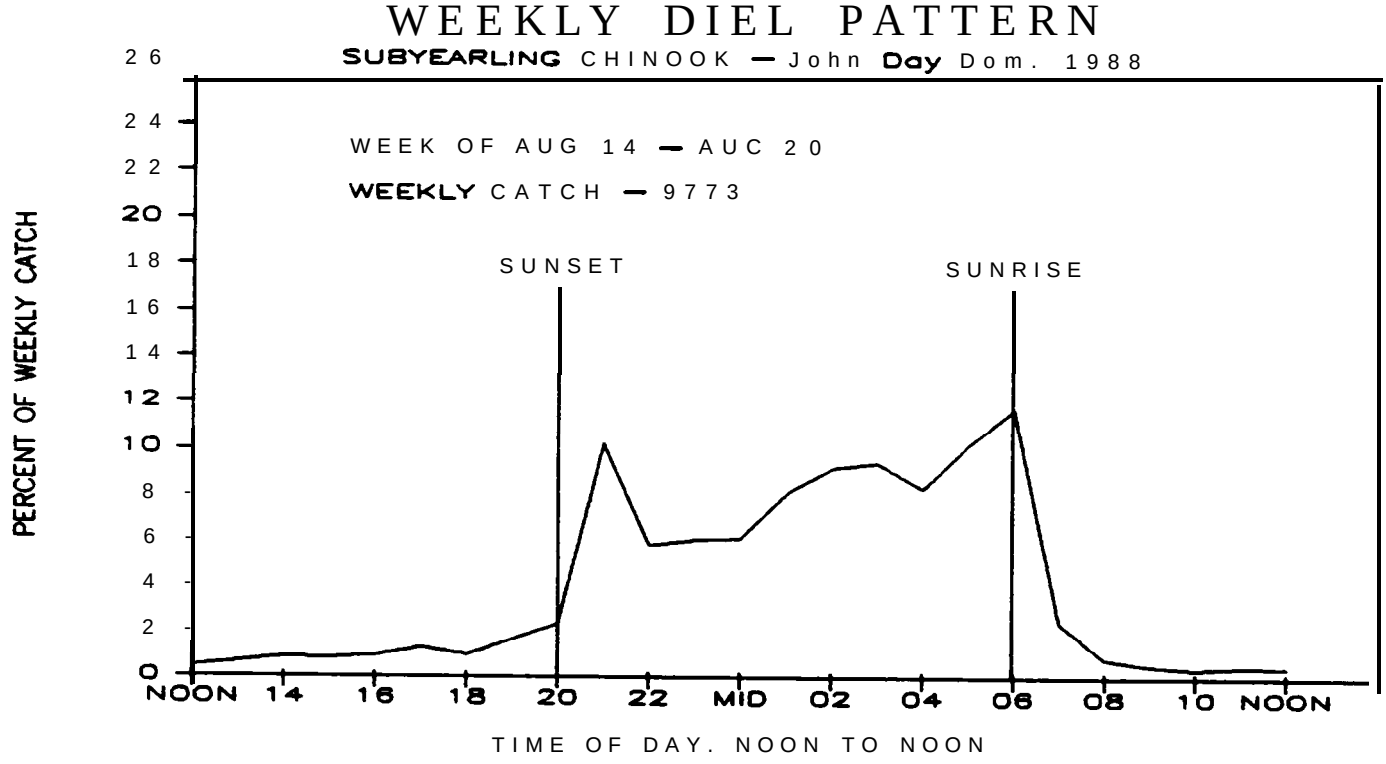

FIGURE 20

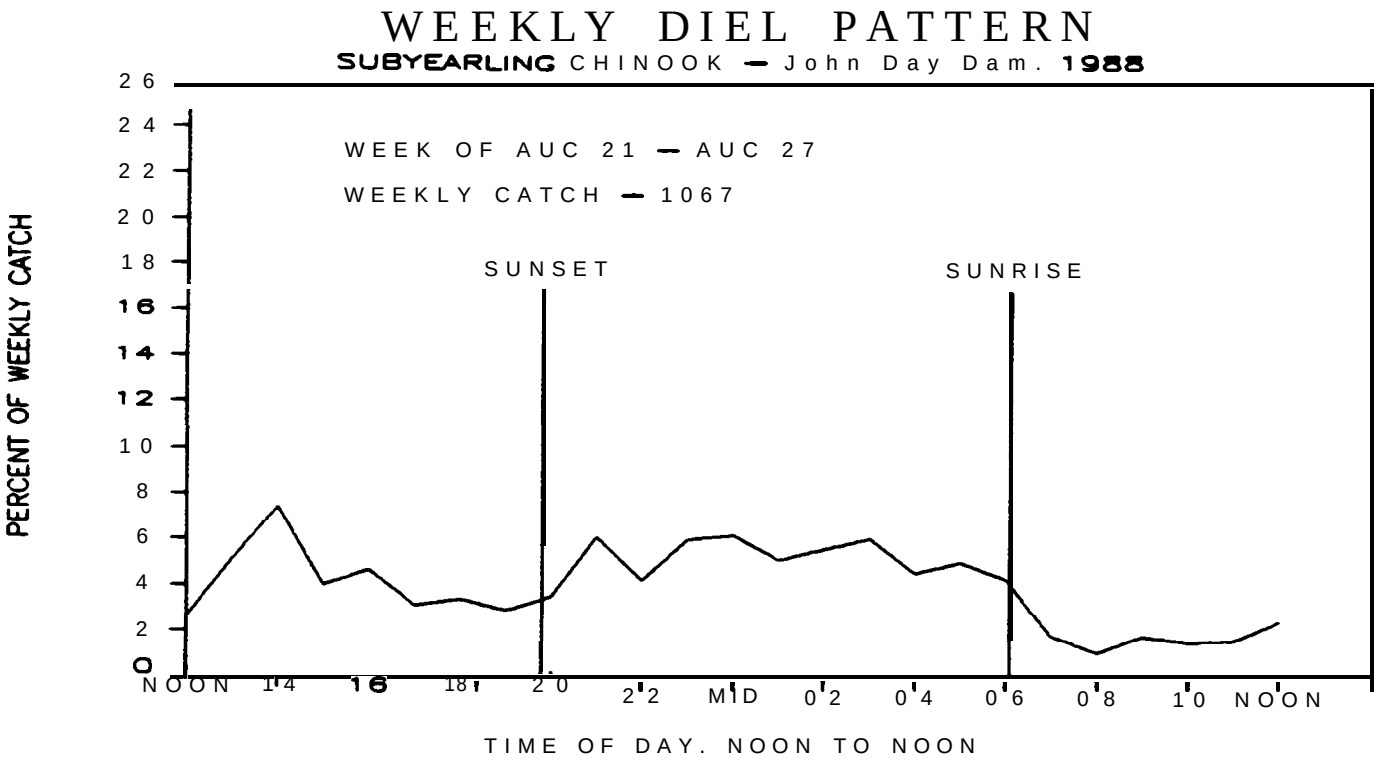

FIGURE 21

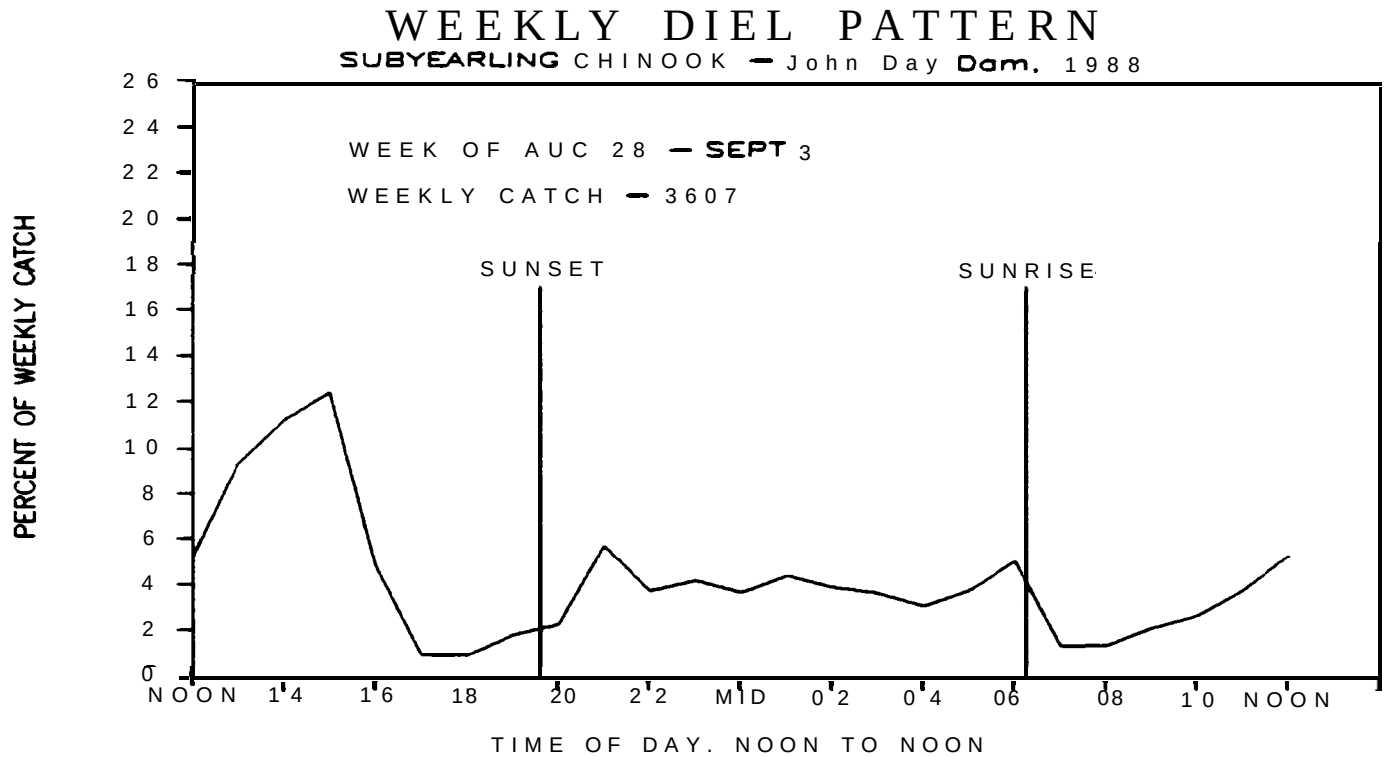

FIGURE 22

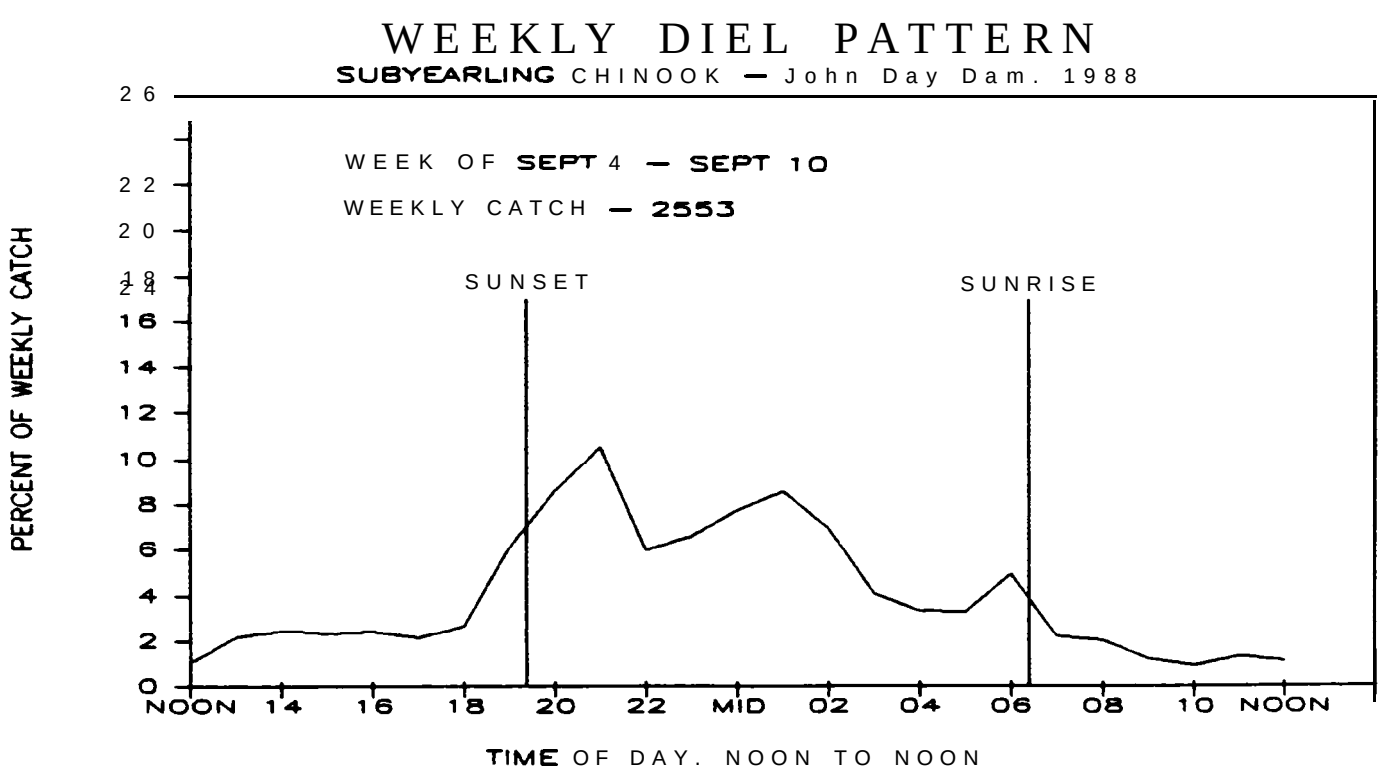

FIGURE 23

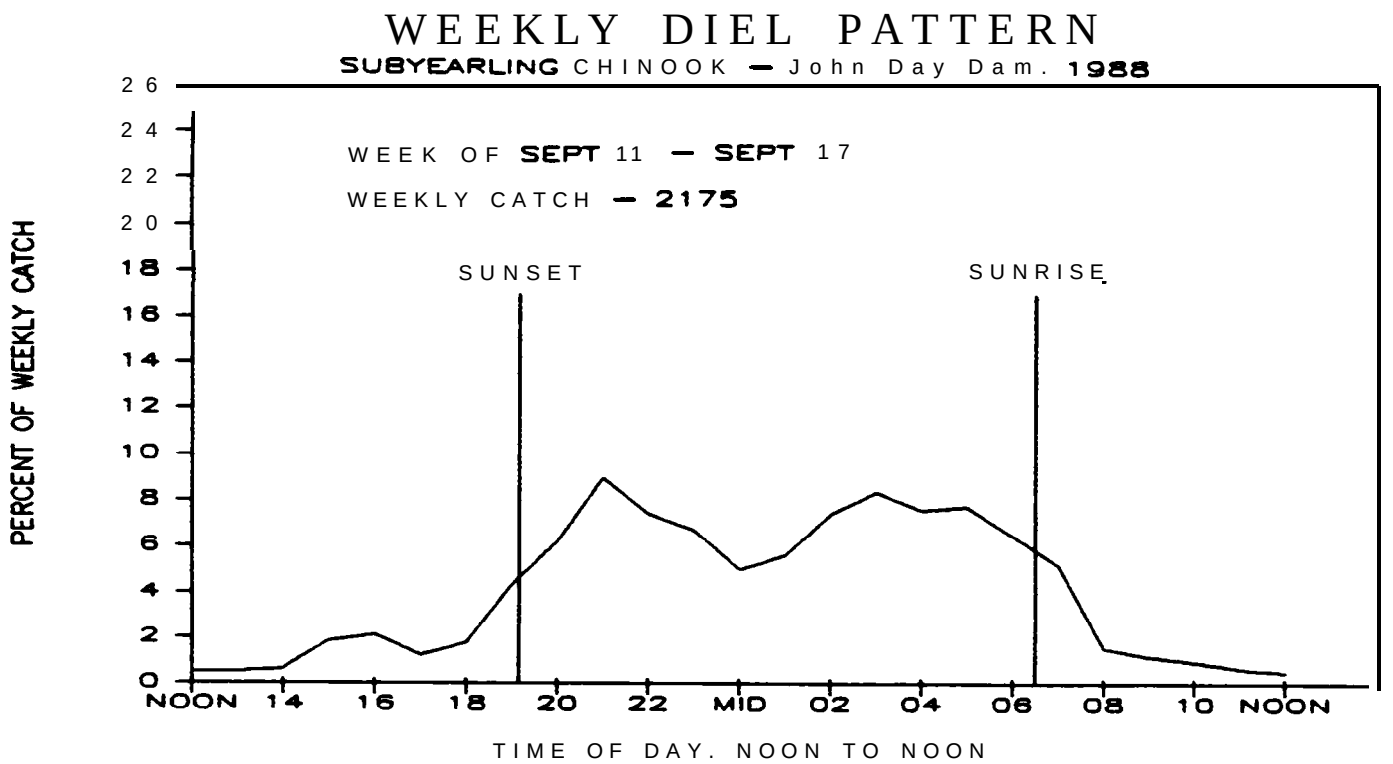

FIGURE 24

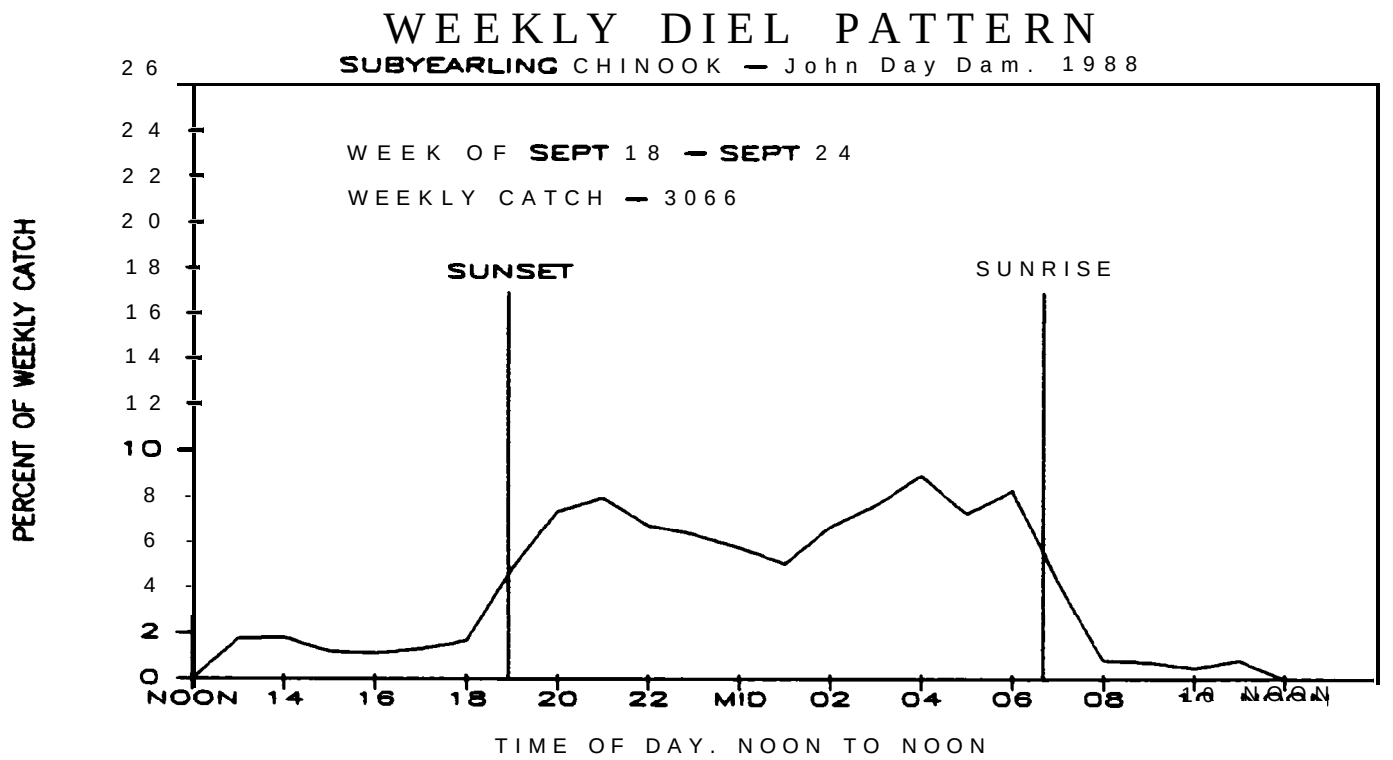

FIGURE 2 s

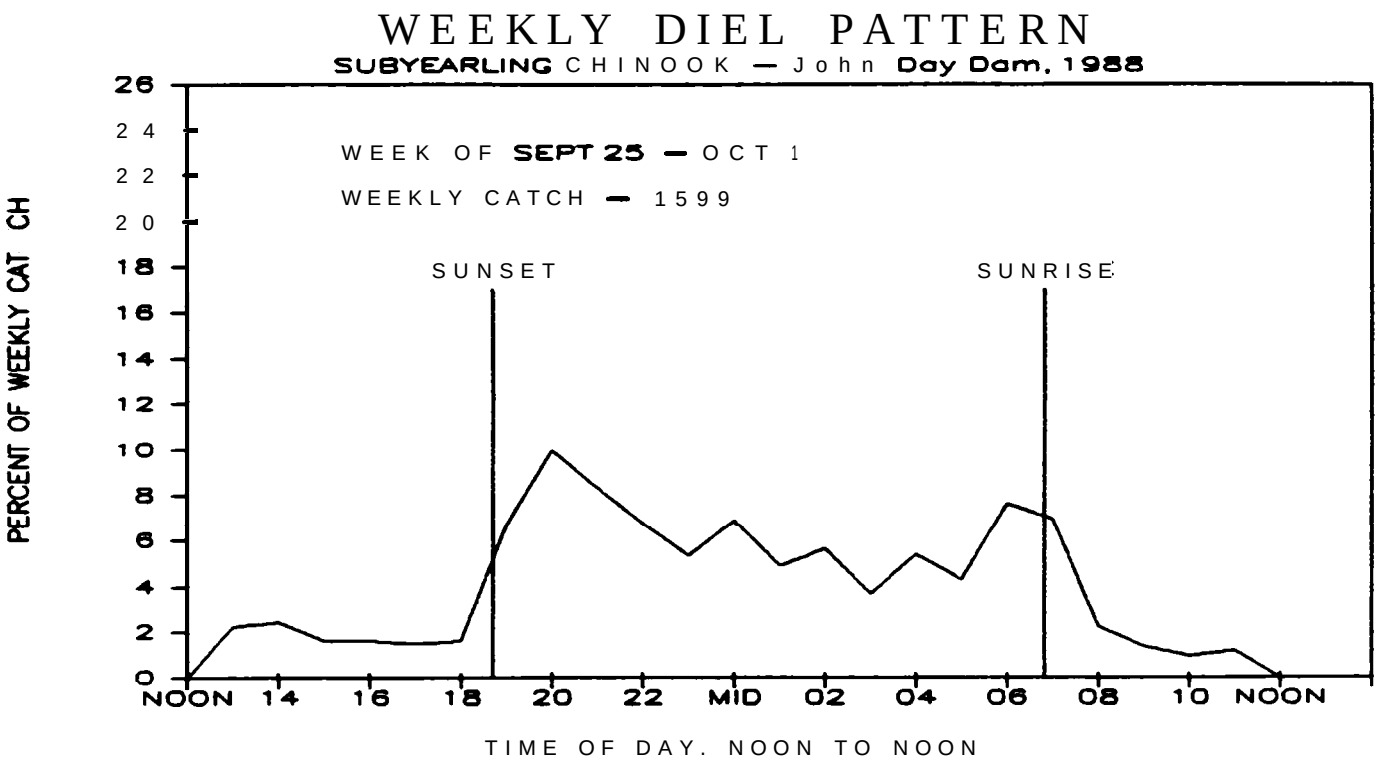

FIGURE 26

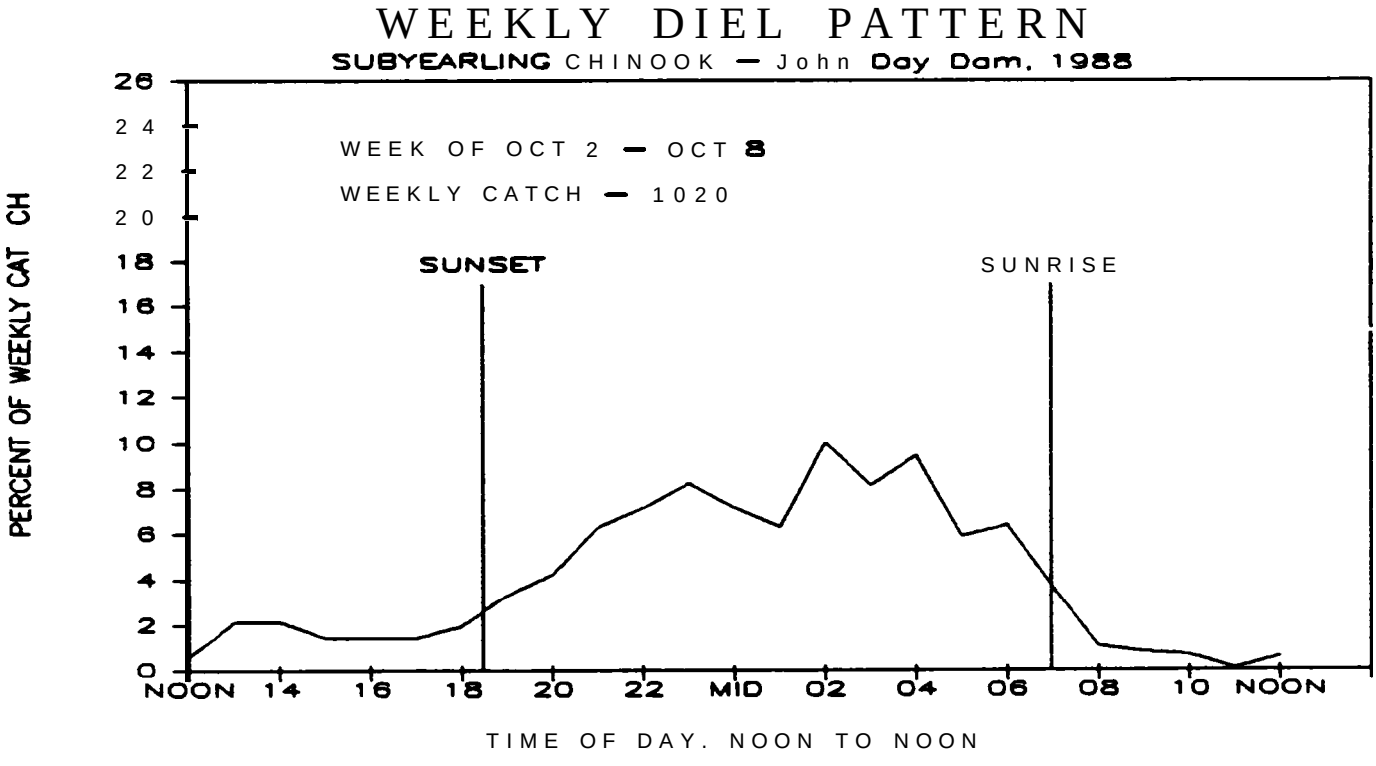

FIGURE 27

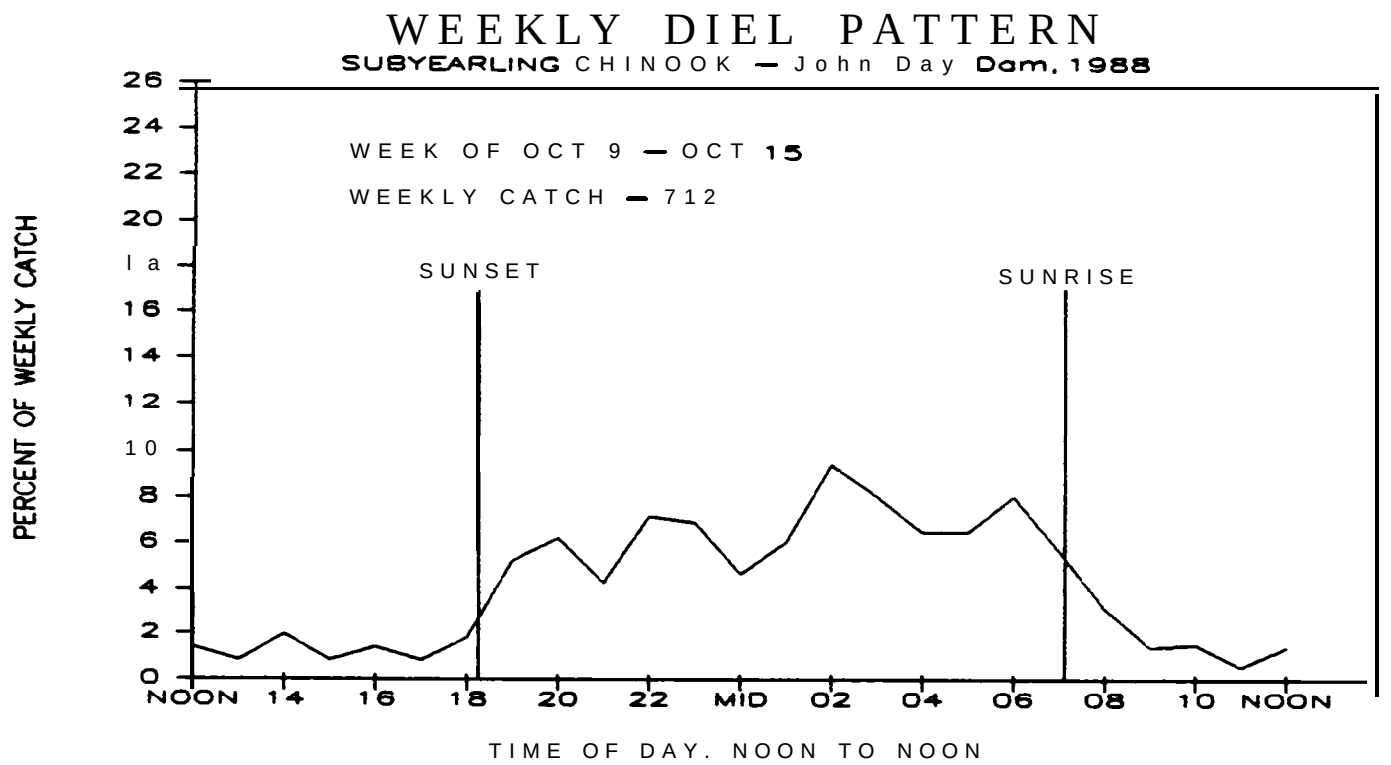

FIGURE 28

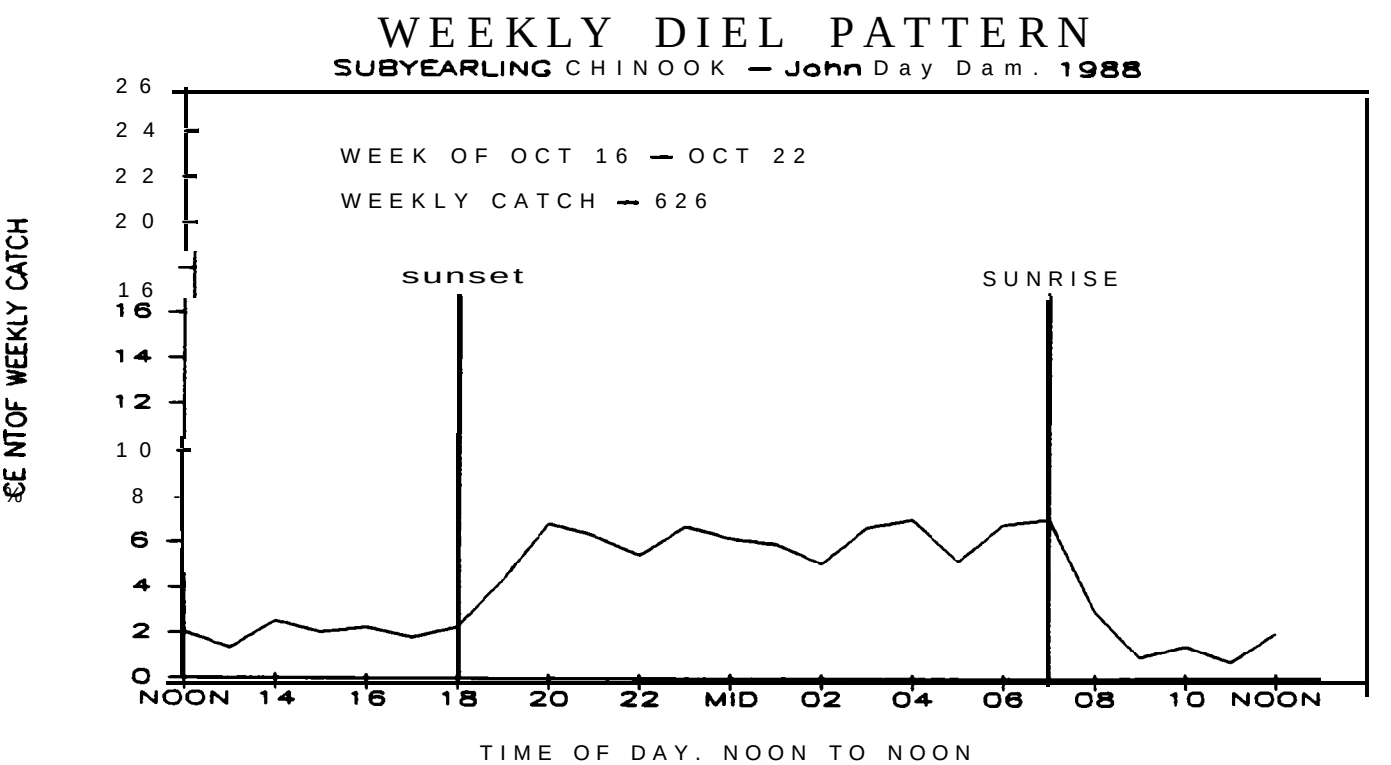

FIGURE 29

WEEKLY DIEL PATTERN

SUBYEARLING CHINOOK — John **Dav** Dam. 1988

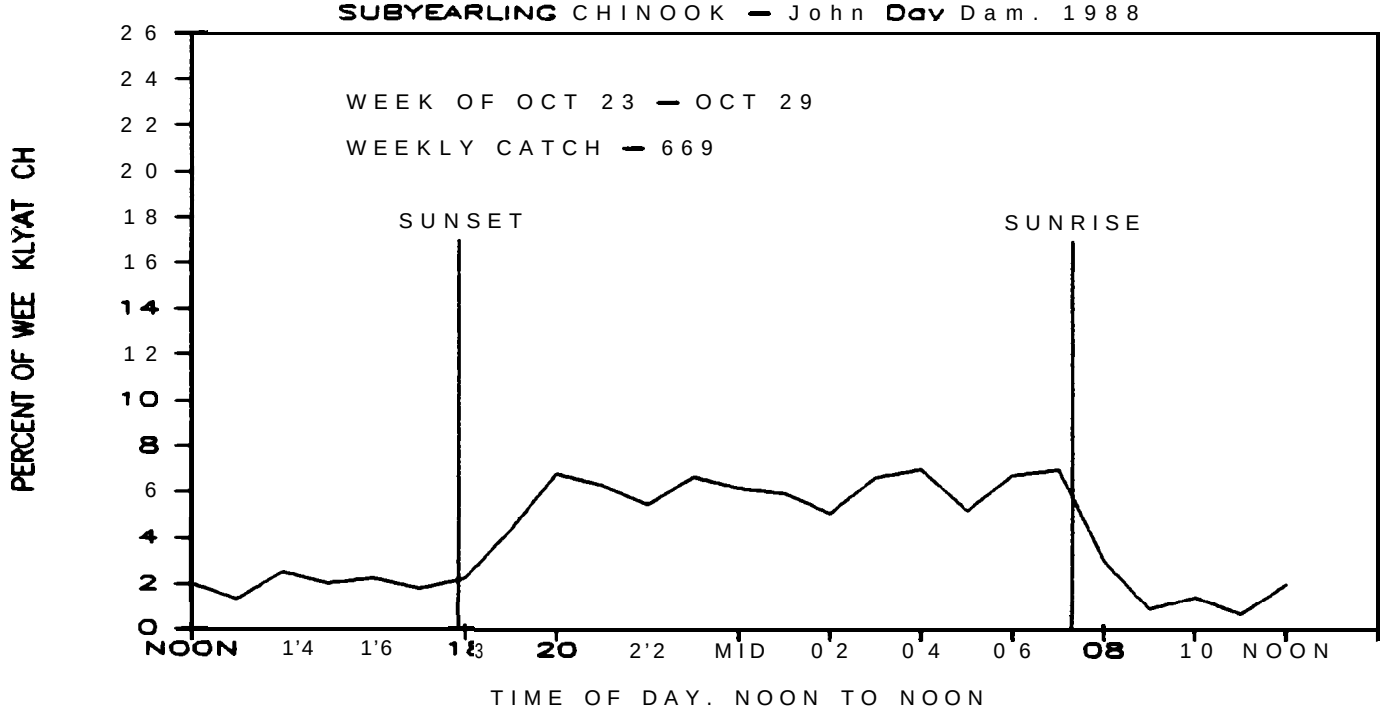

FIGURE **30**

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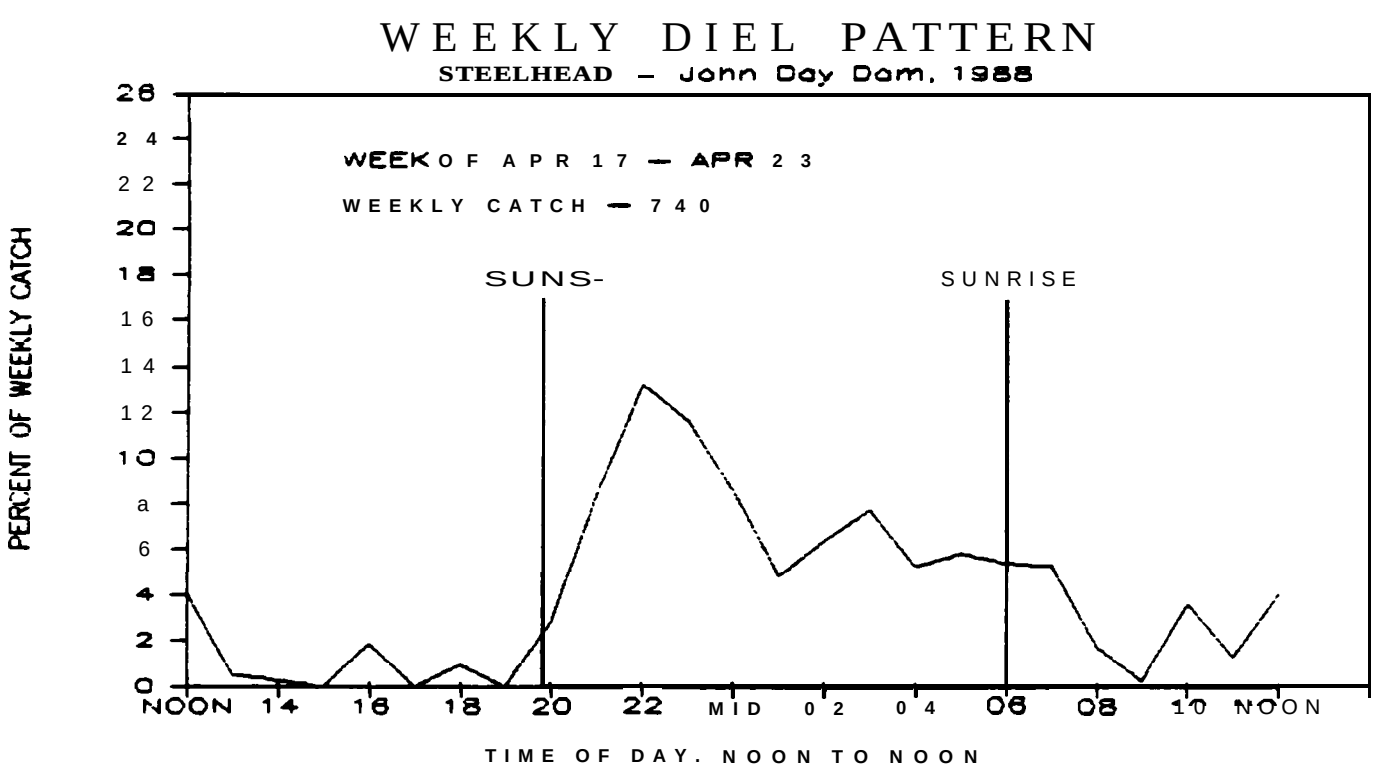

FIGURE 31

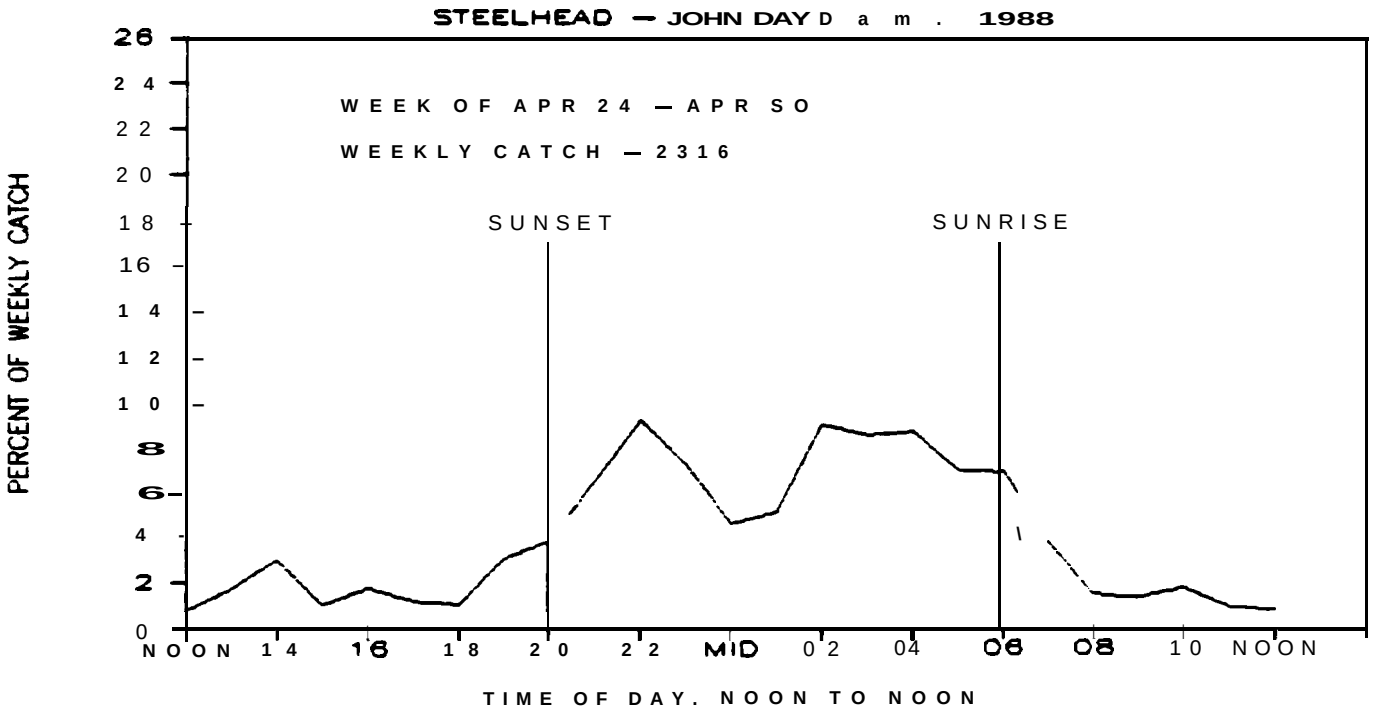

FIGURE 32

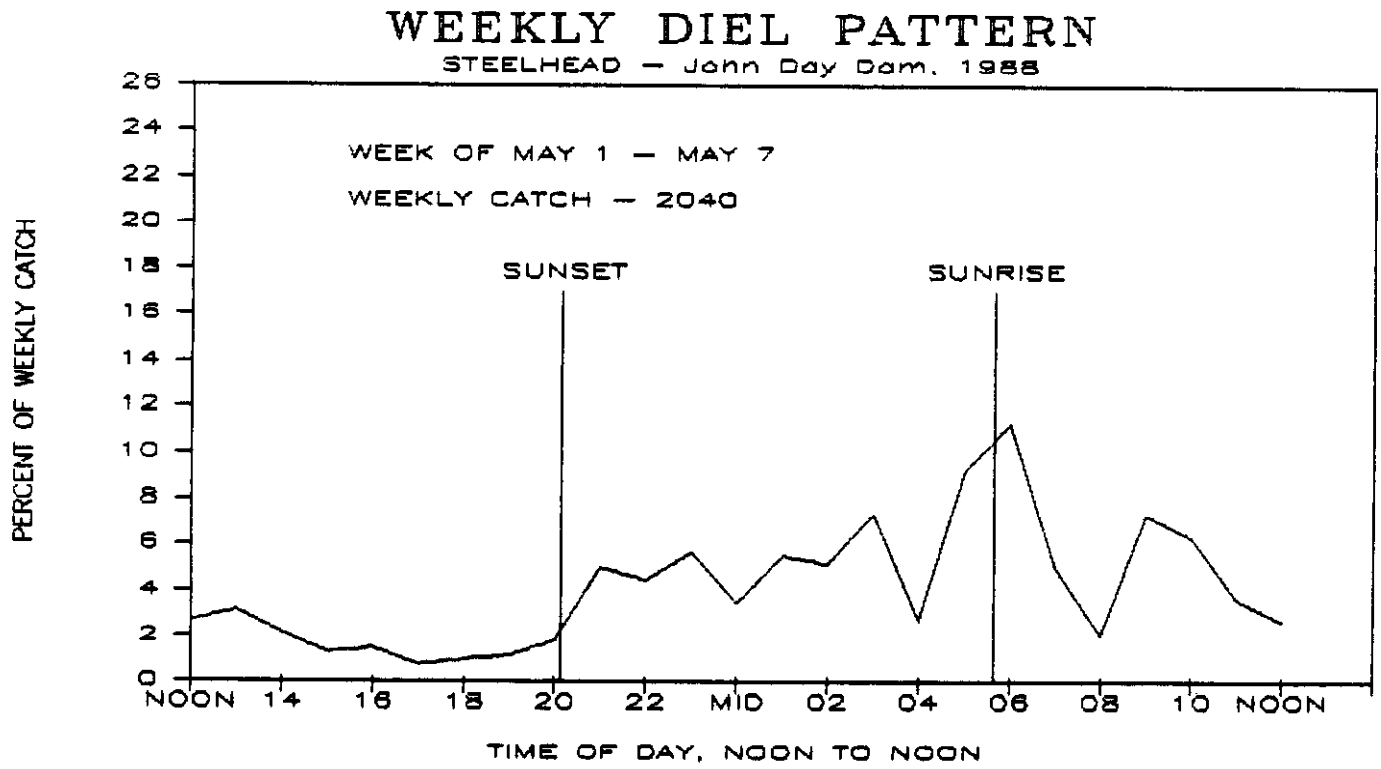

FIGURE 33

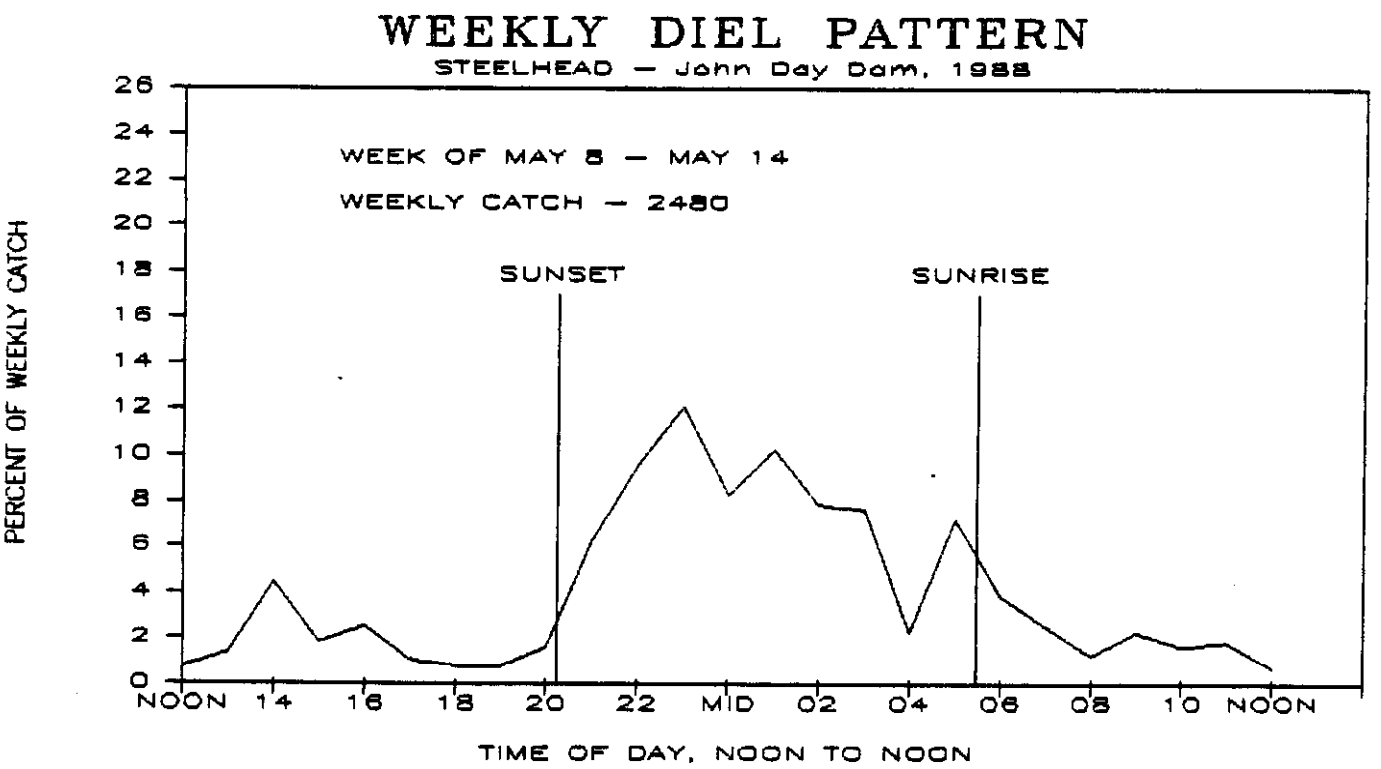

FIGURE 34

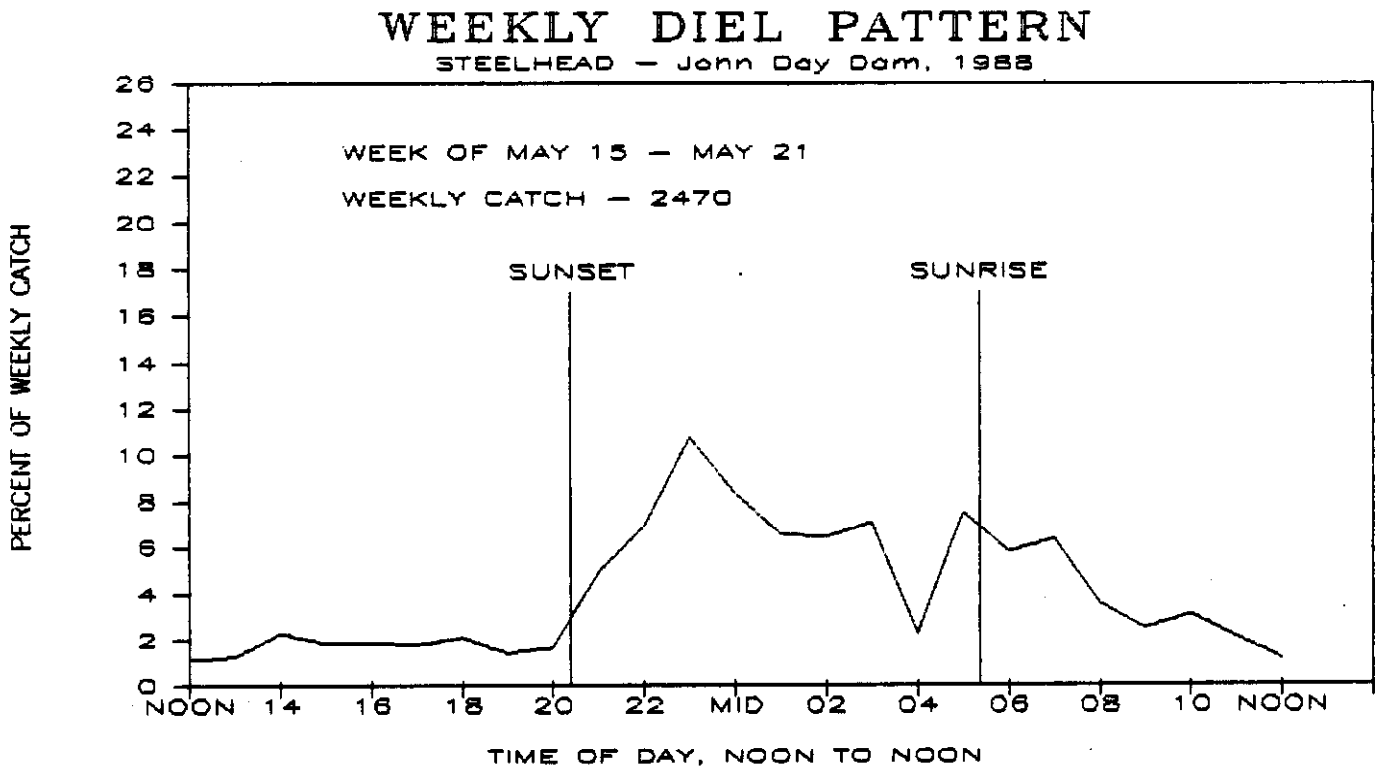

FIGURE 35

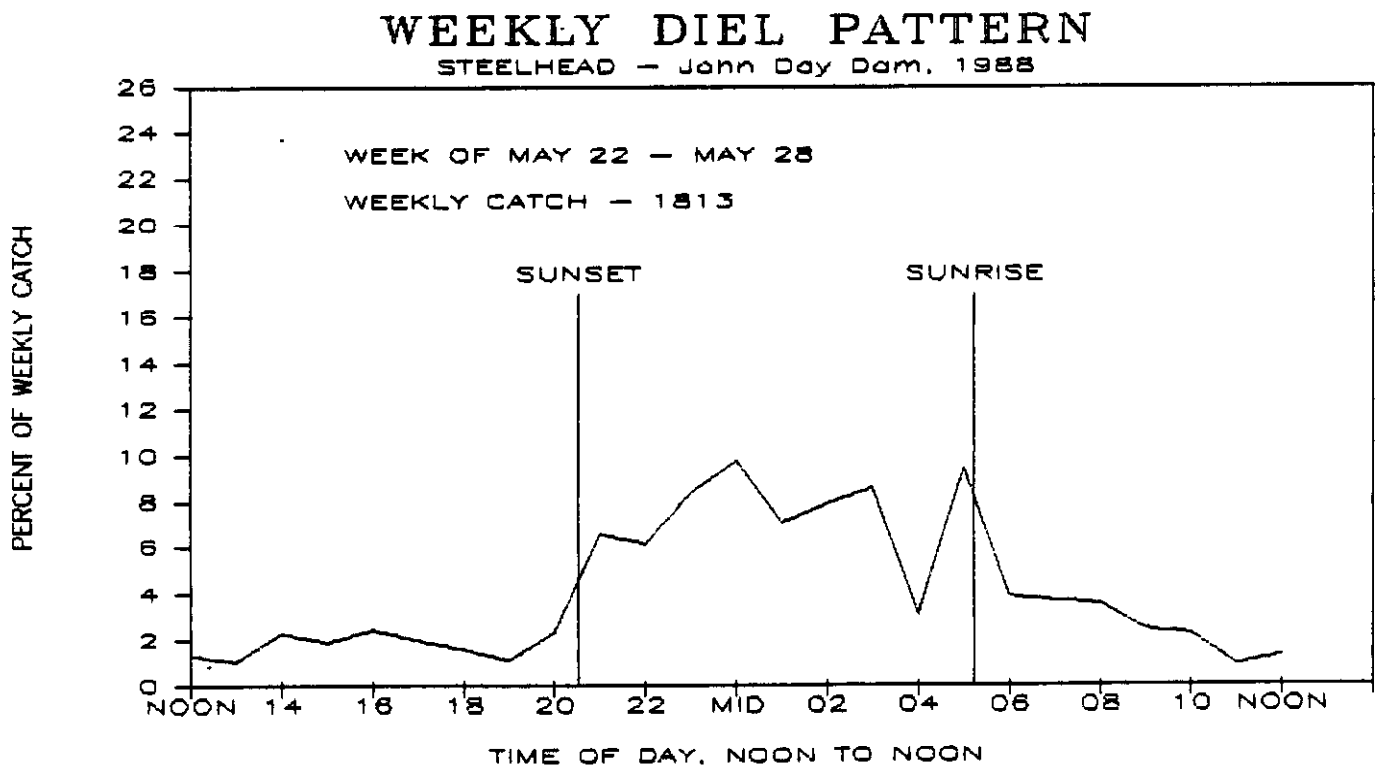

FIGURE 36

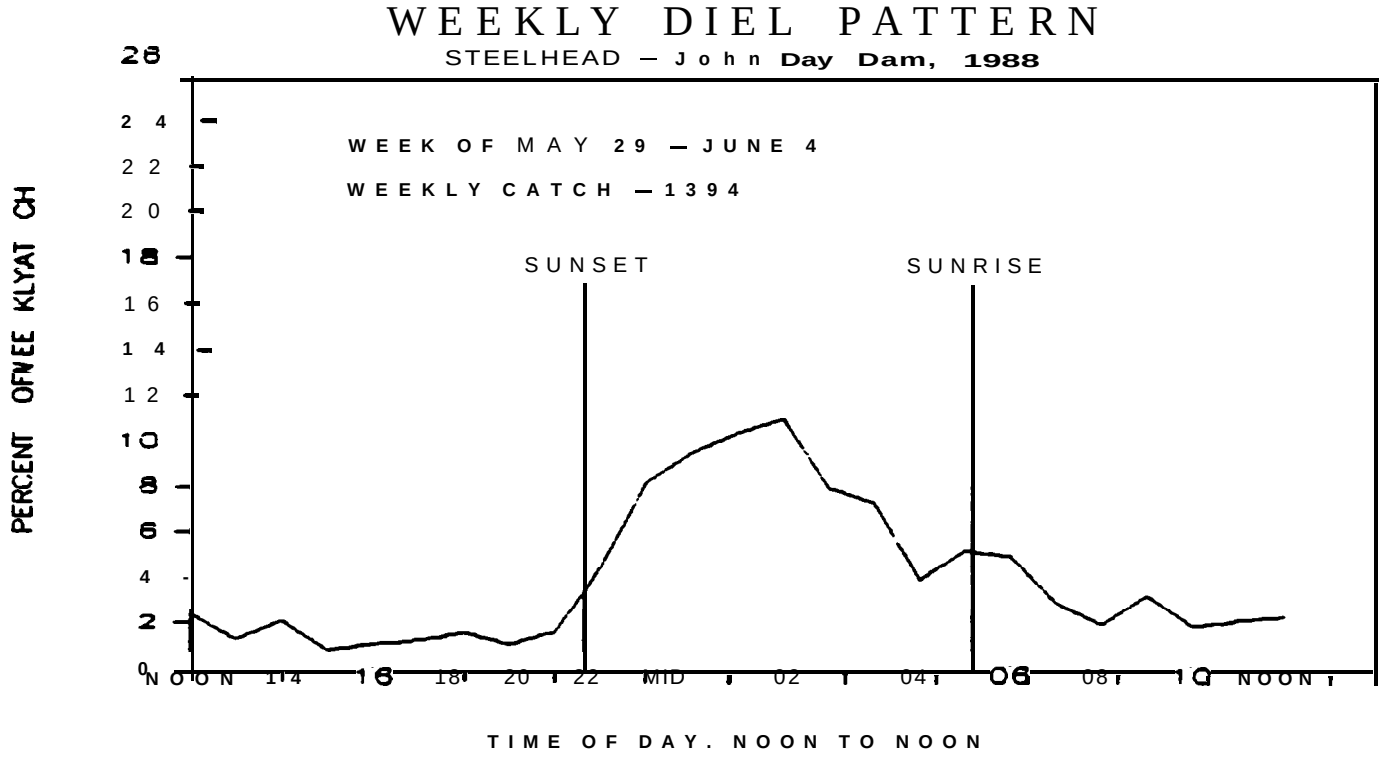

FIGURE 37

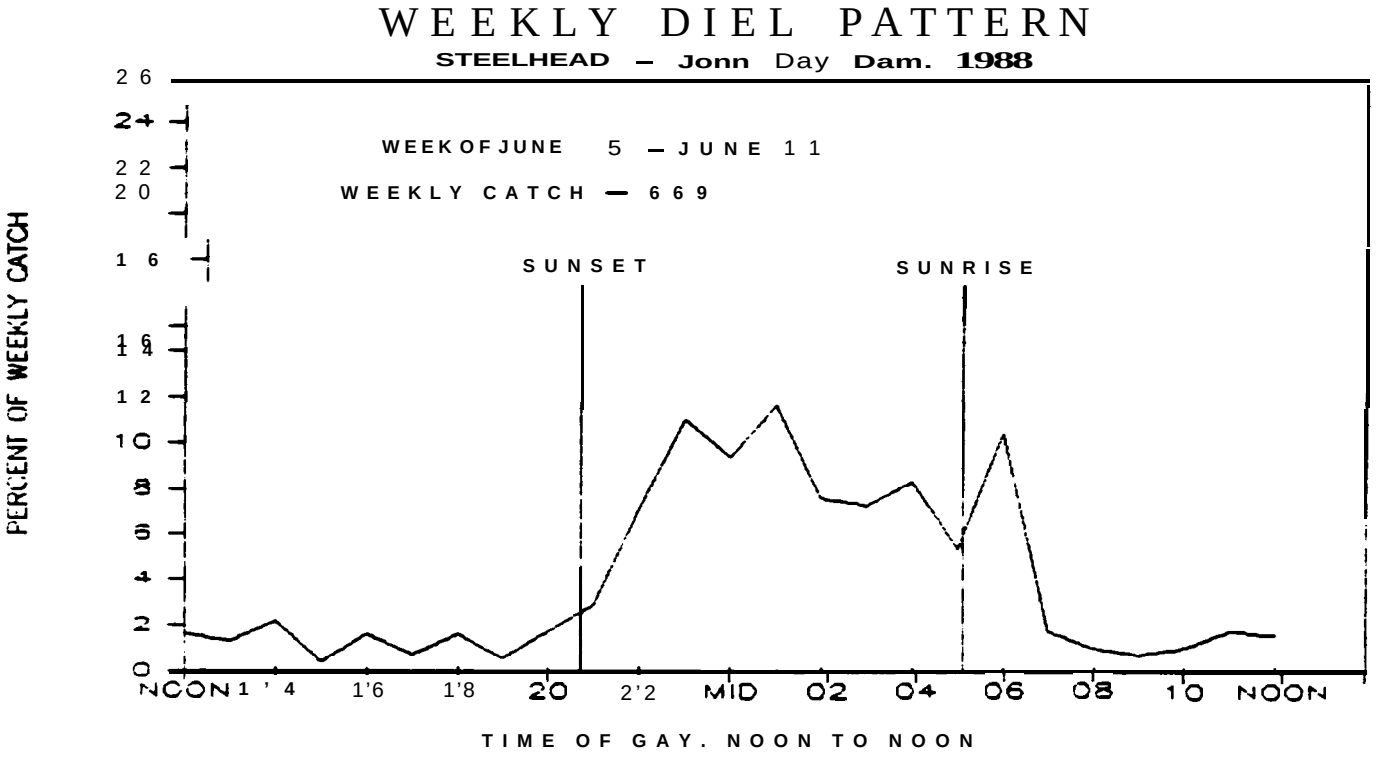

FIGURE 38

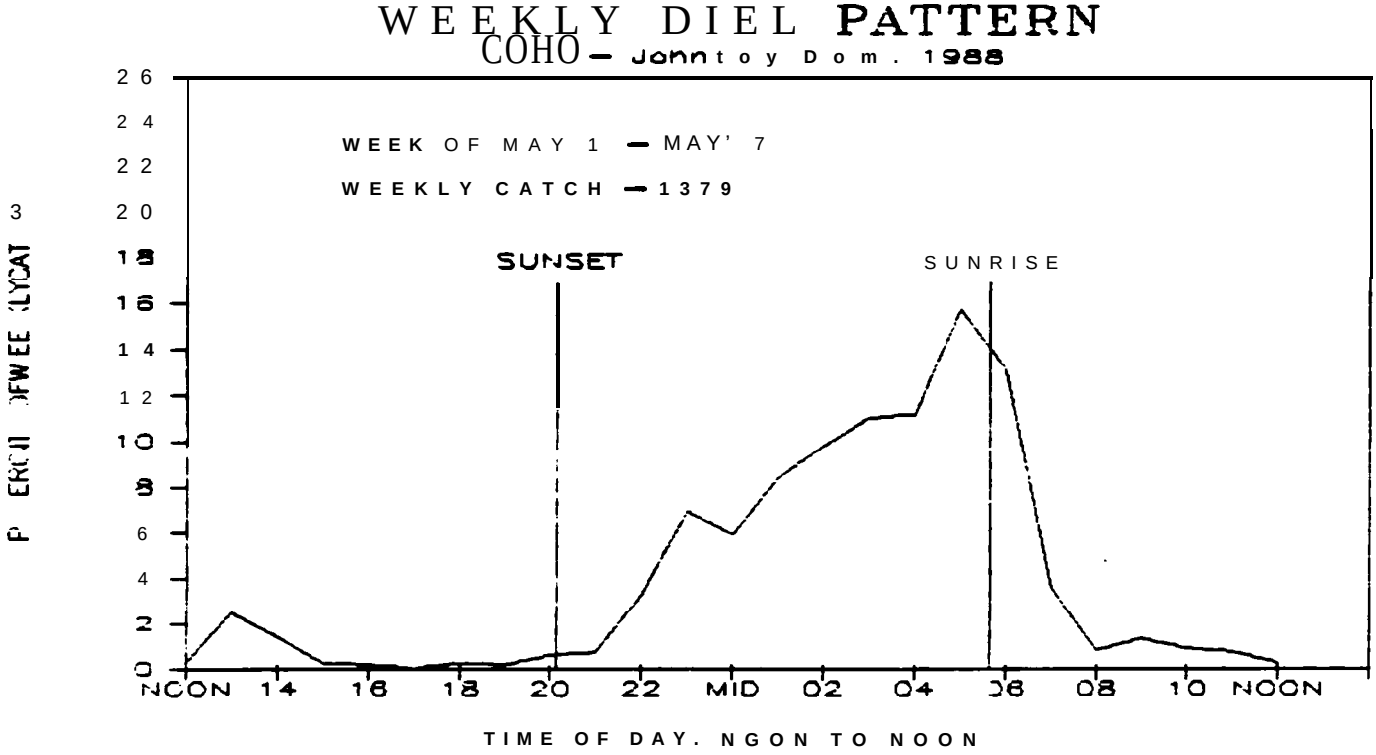

FIGURE 39

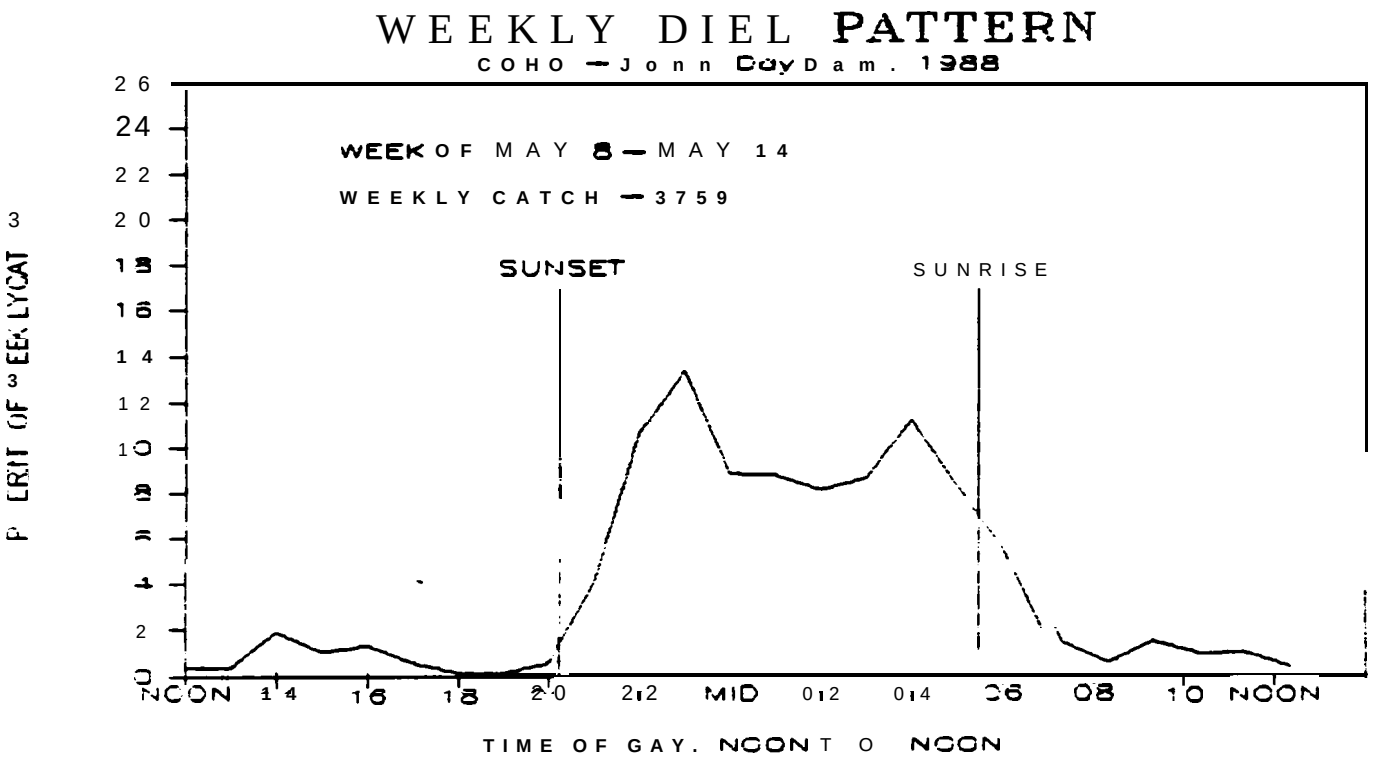

FIGURE 40

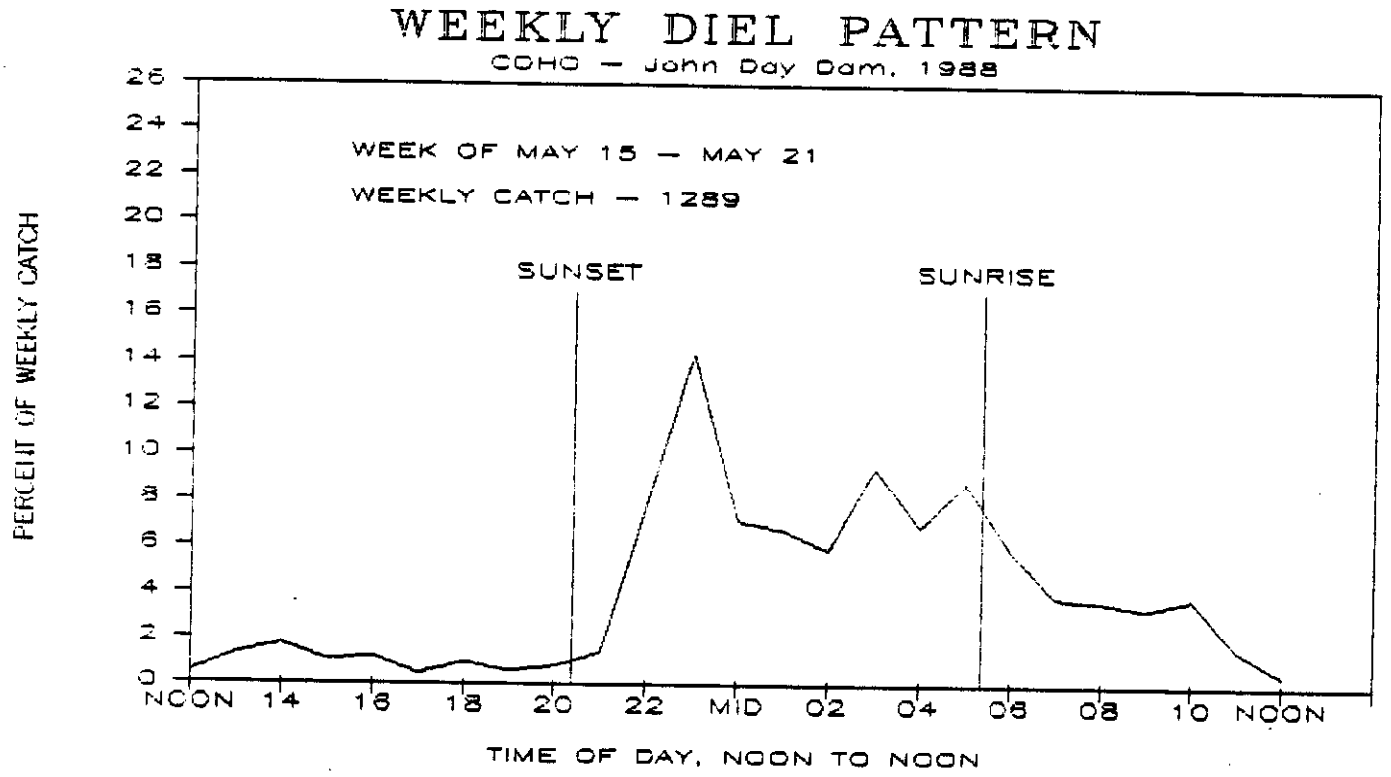

FIGURE 41

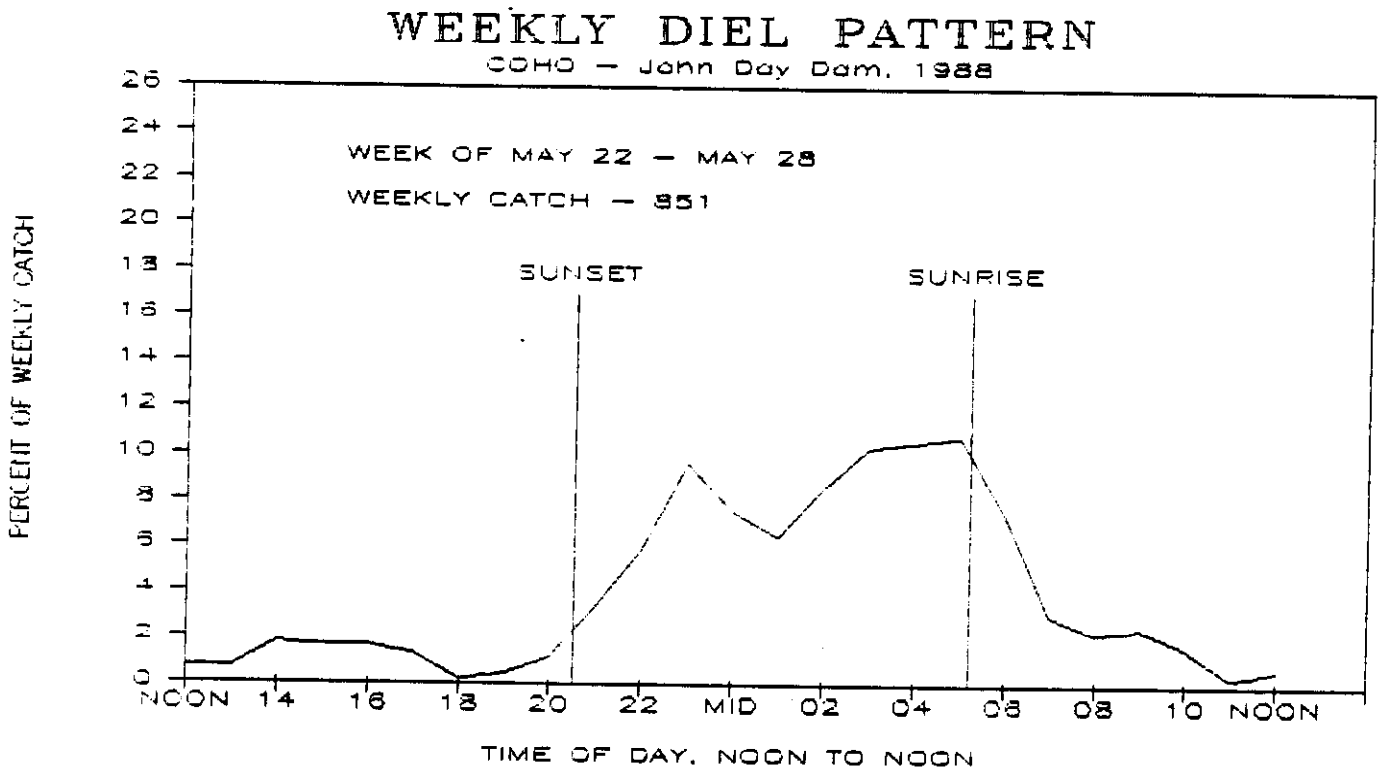

FIGURE 42

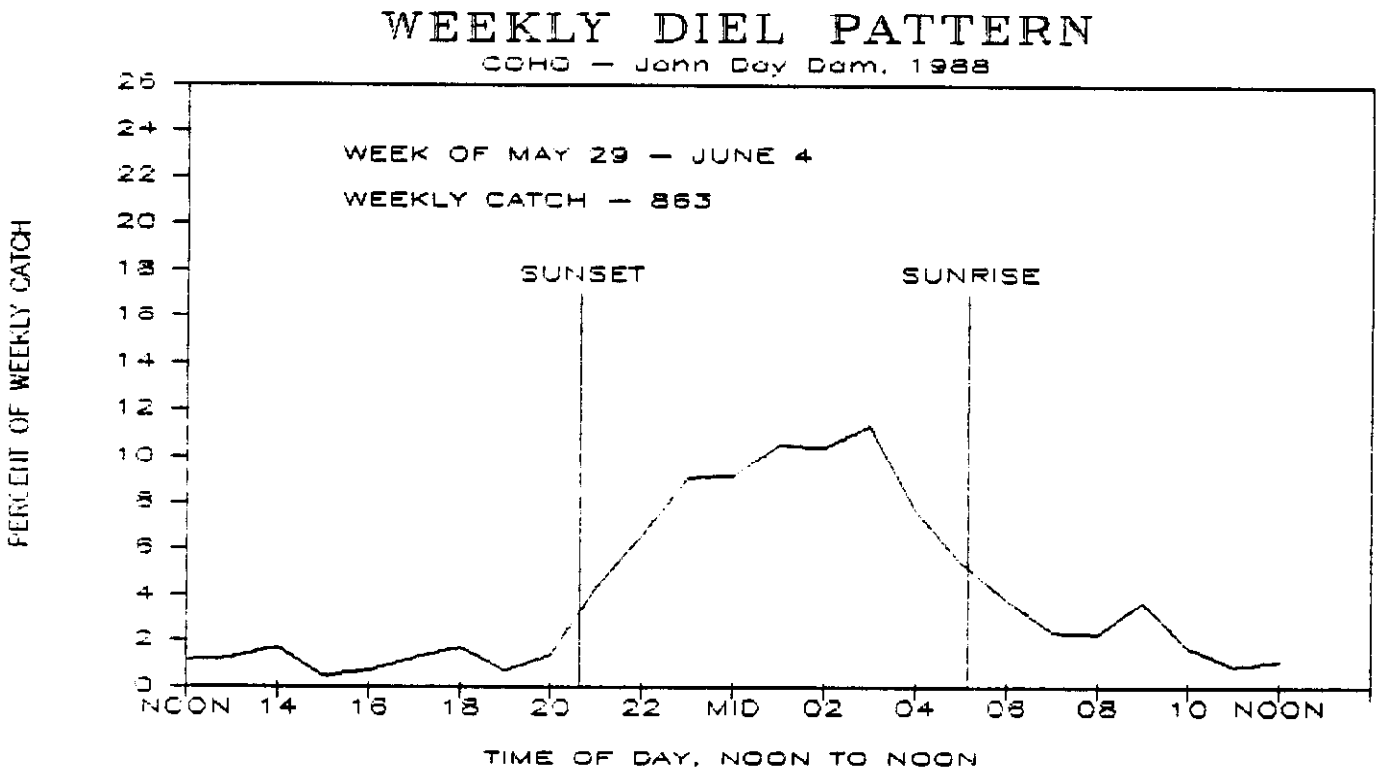
WEEKLY DIEL PATTERN
COHO — John Day Dam, 1988
WEEK OF MAY 29 — JUNE 4
WEEKLY CATCH — 863
SUNSET
SUNRISE
PERCENT OF WEEKLY CATCH
0
2
4
6
8
10
12
14
16
18
20
22
24
26
NOON 14 16 18 20 22 MID 02 04 06 08 10 NOON
TIME OF DAY, NOON TO NOON

FIGURE 43

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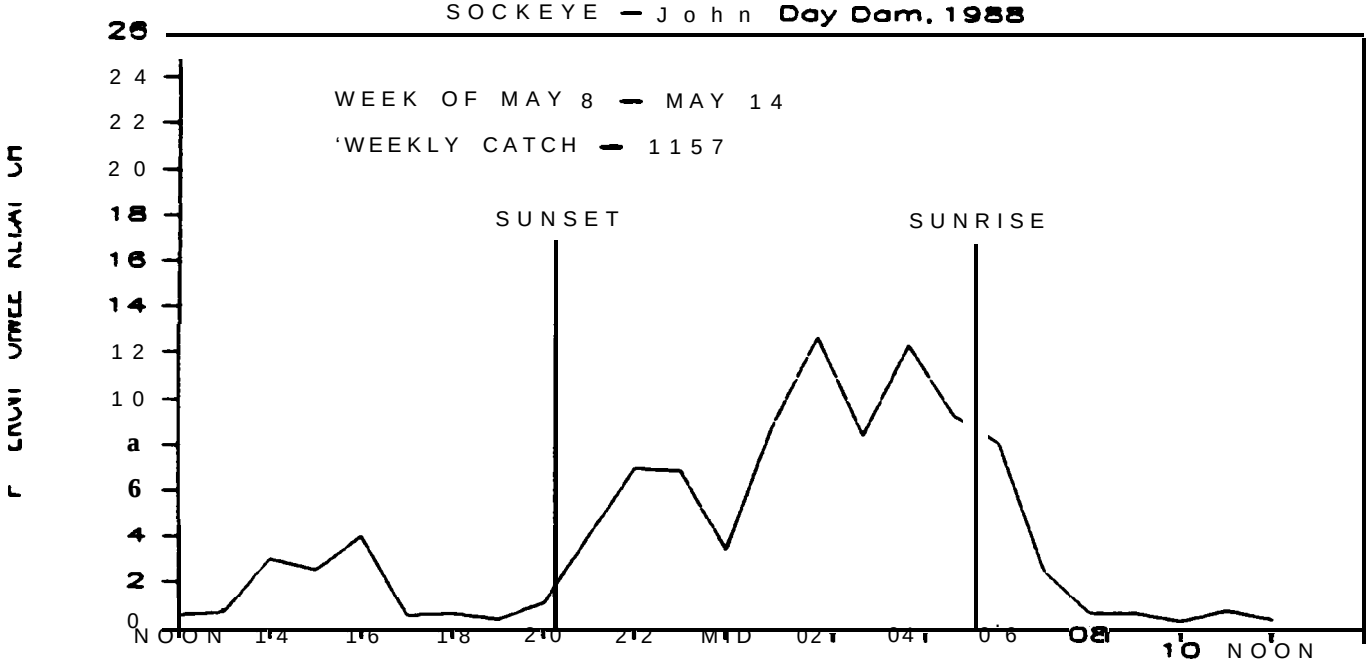
WEEKLY DIEL PATTERN

SOCKEYE — John Day Dam, 1988

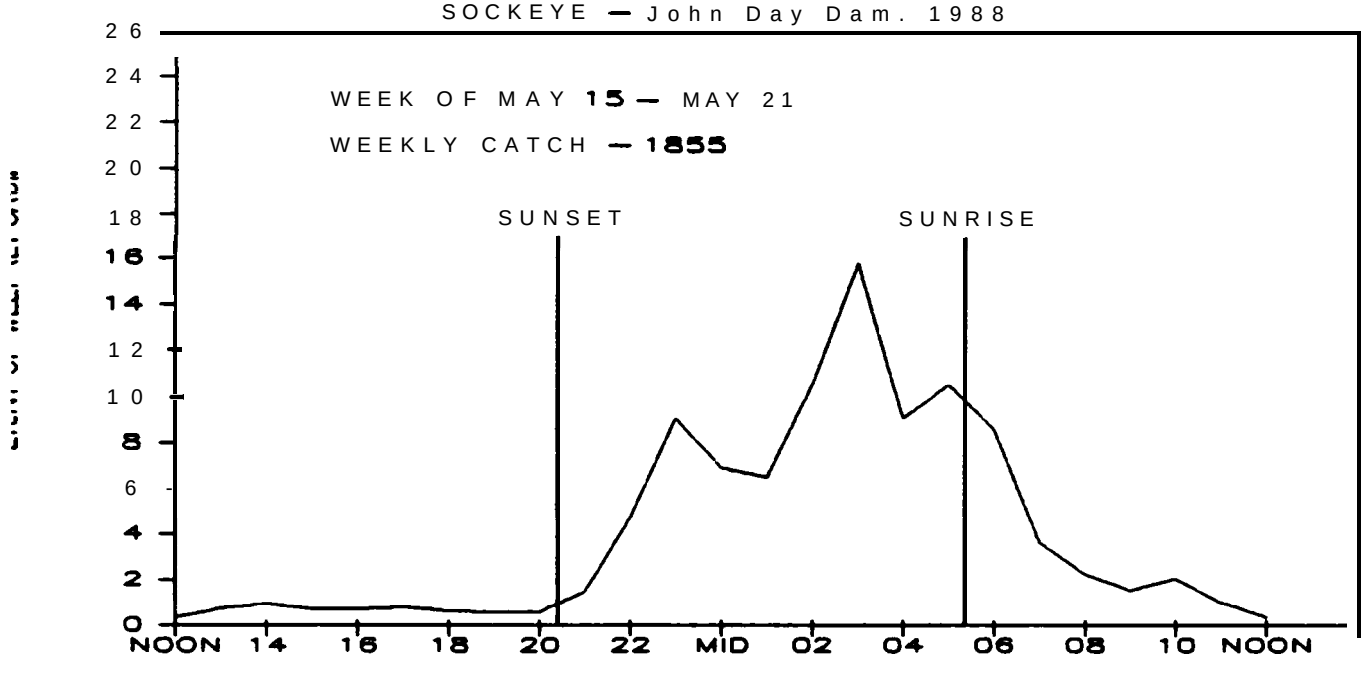


TIME OF DAY NOON TO NOON

FIGURE 44

WEEKLY DIEL PATTERN

SOCKEYE — John Day Dam. 1988



TIME OF DAY, NOON TO NOON

FIGURE 45

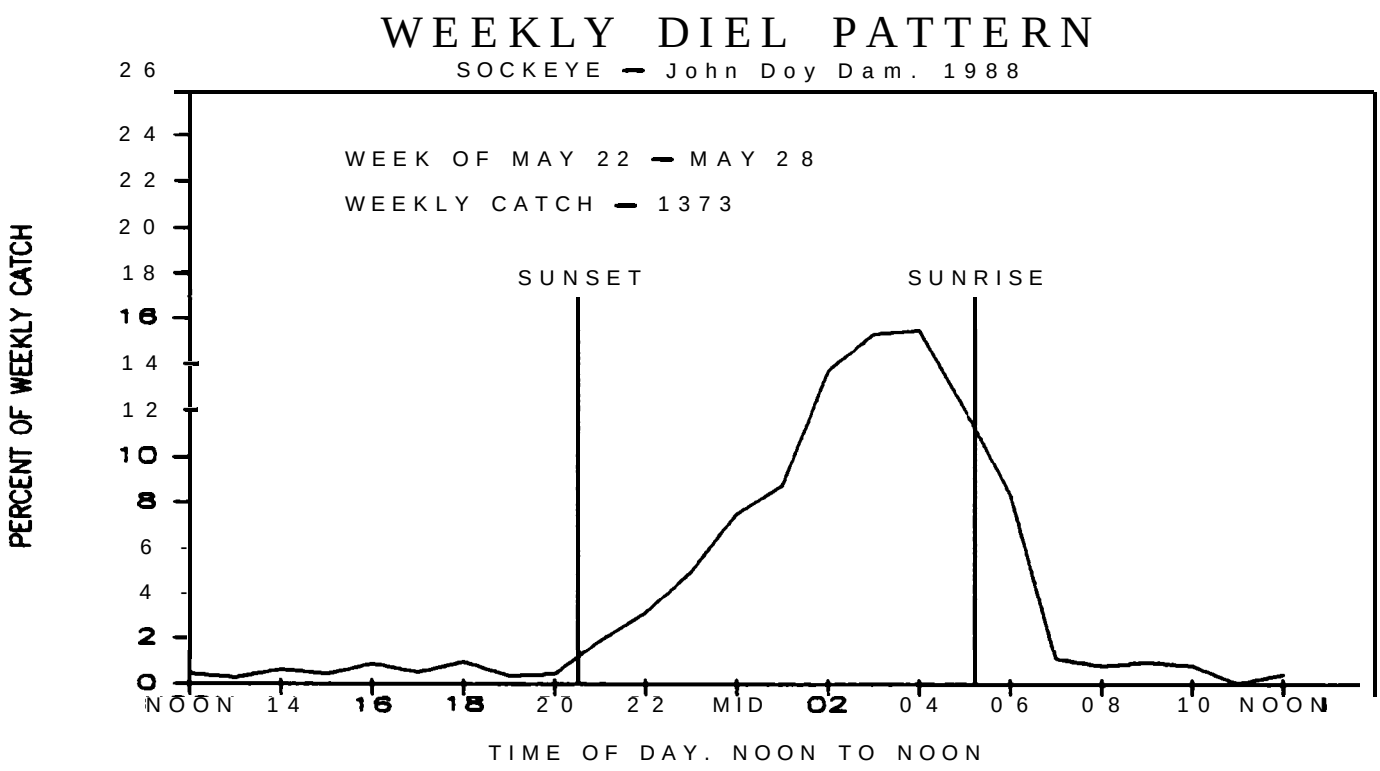


FIGURE 46

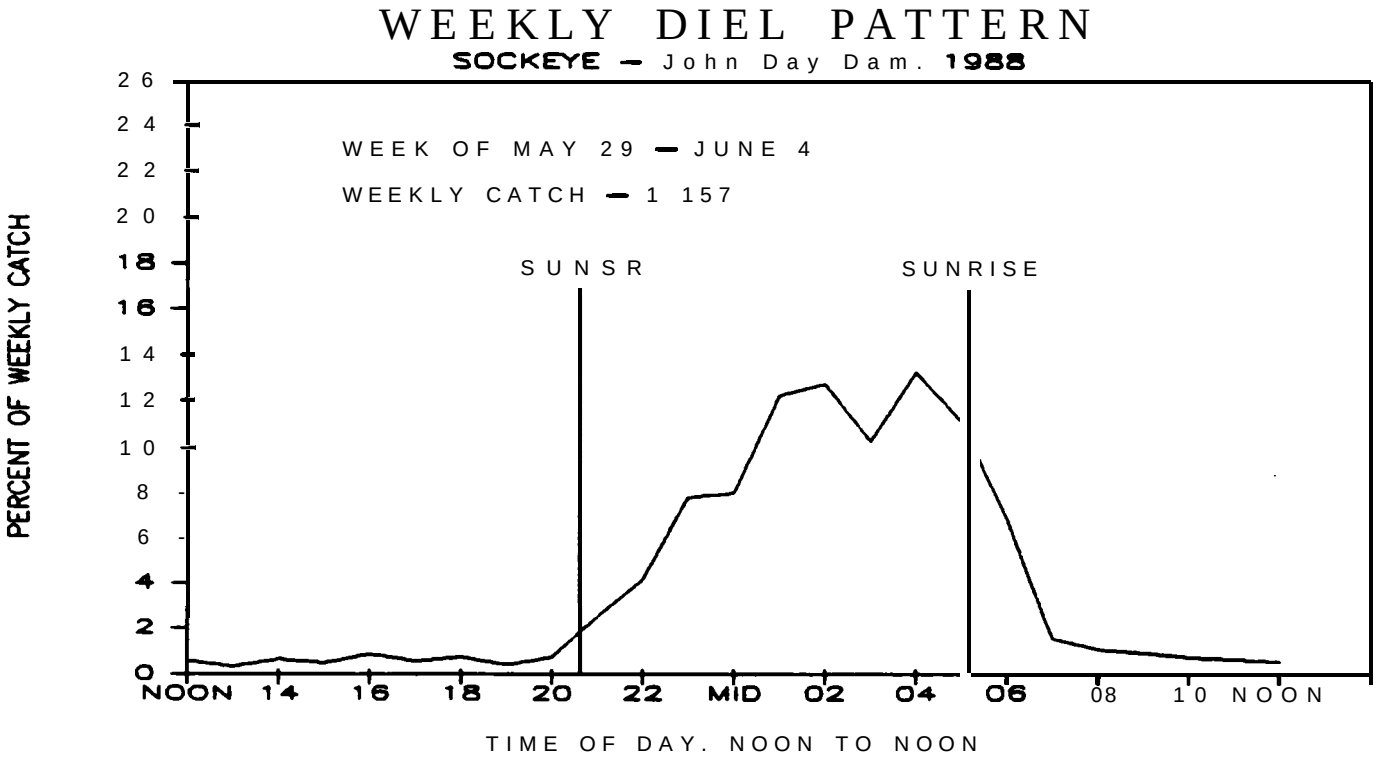


FIGURE 47

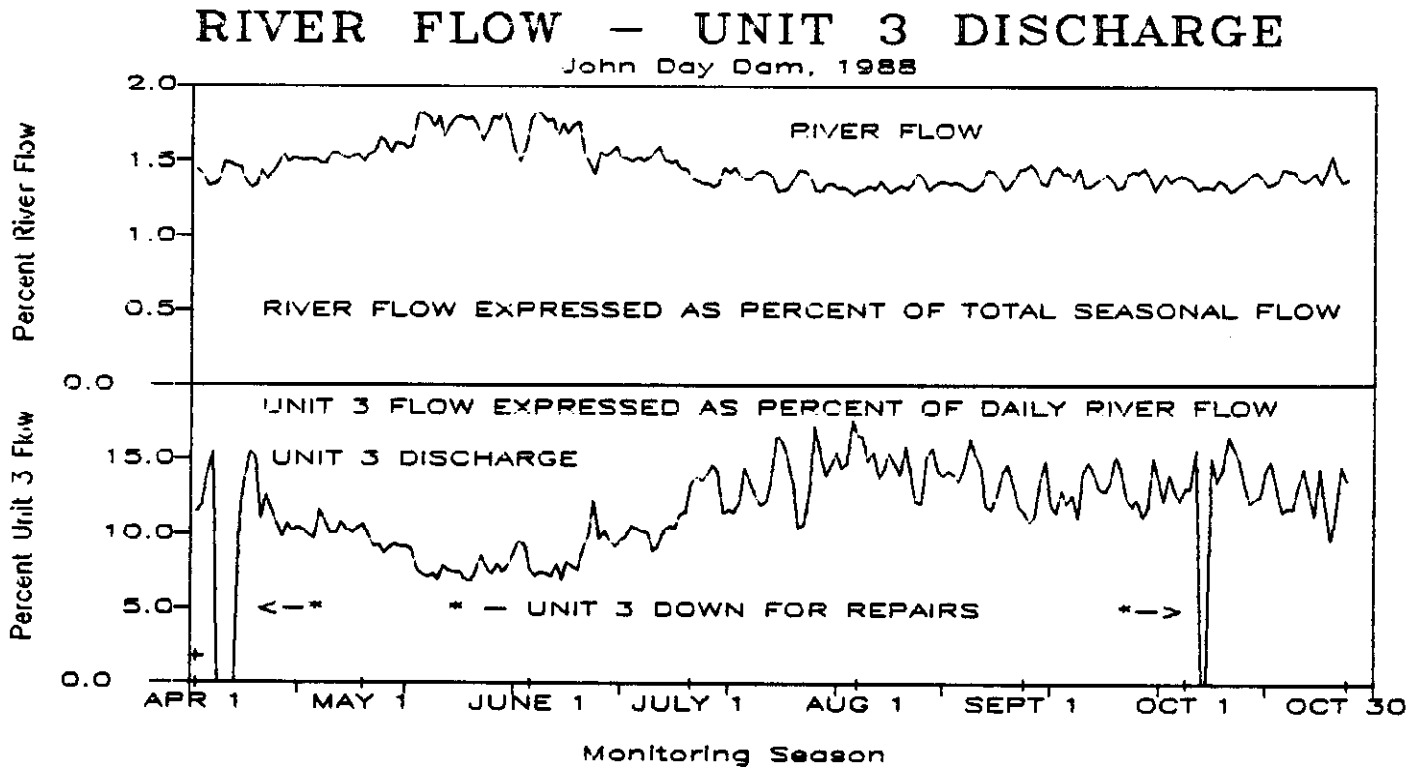


FIGURE 48

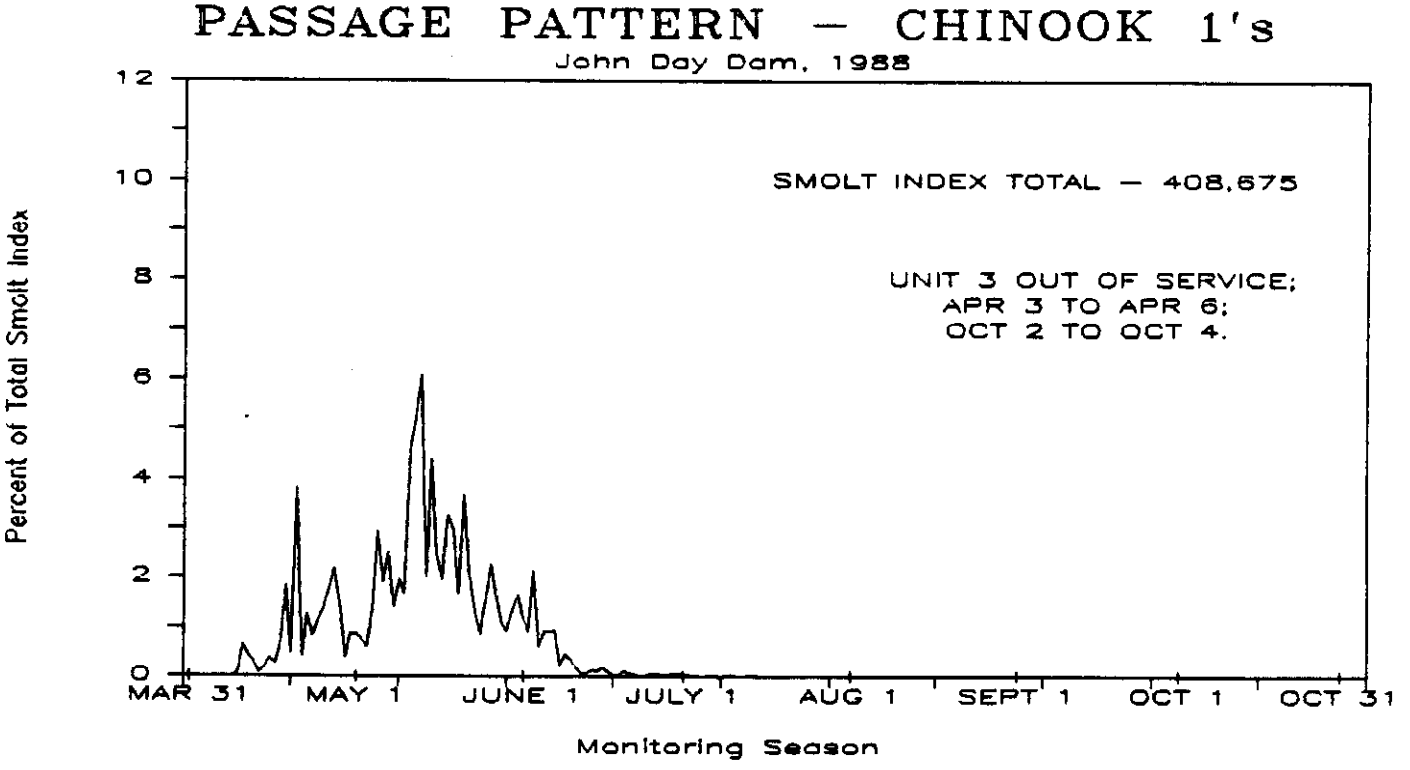


FIGURE 49

PASSAGE PATTERN — CHINOOK O's

John Day Dam. 1988

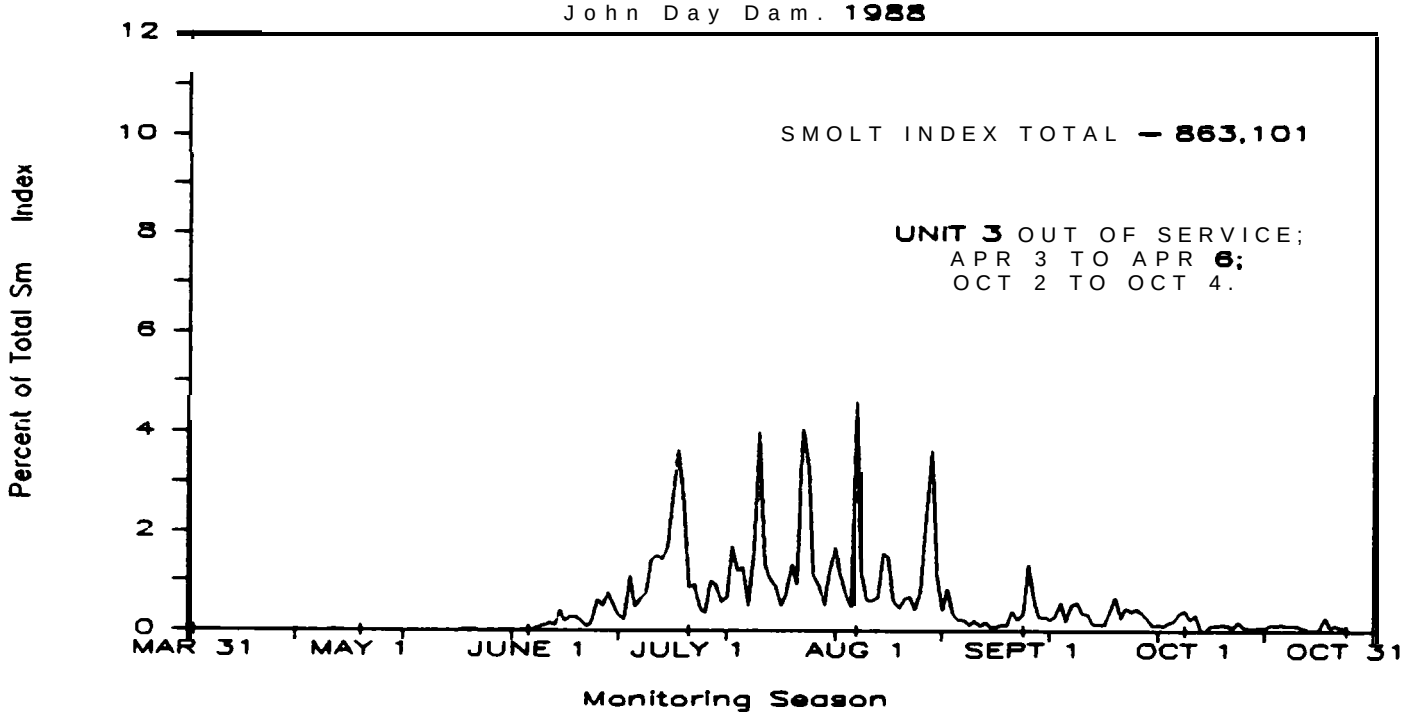


FIGURE 50

PASSAGE PATTERN — STEELHEAD

John Day Dam, 1988

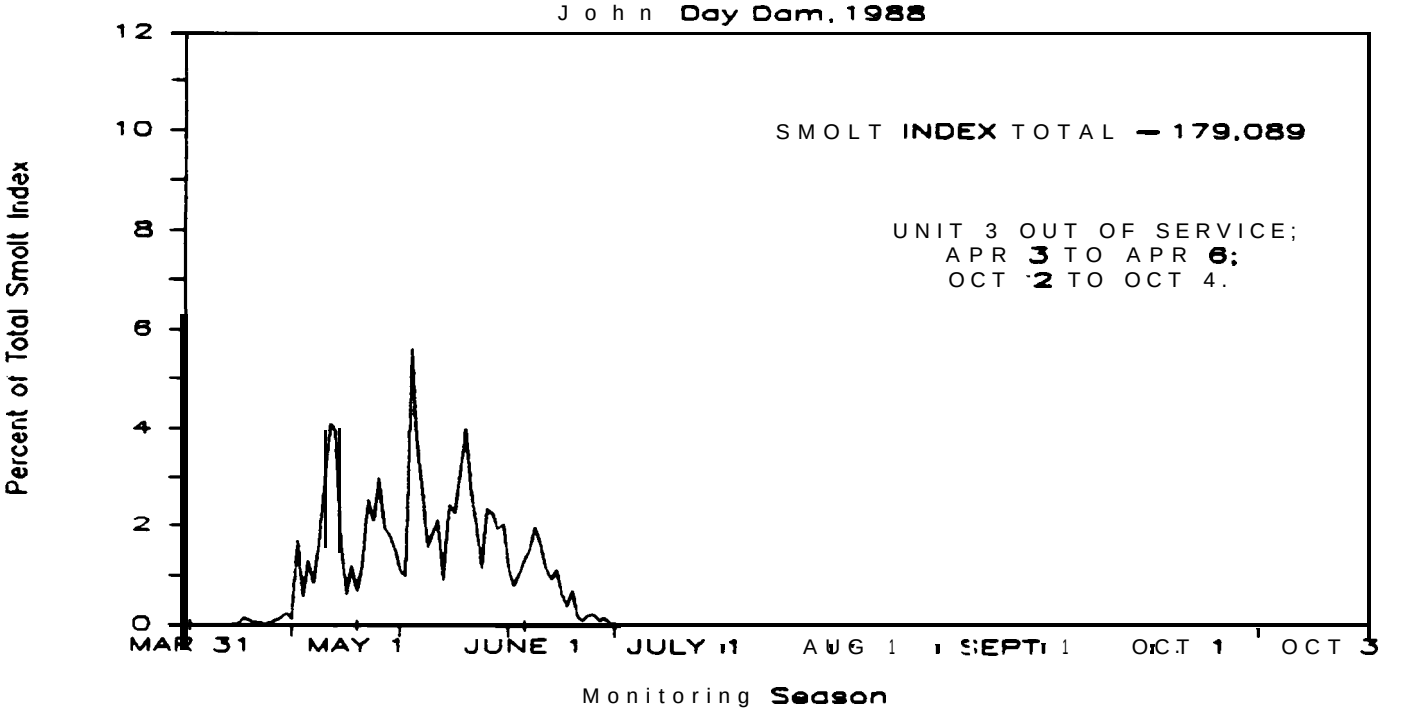


FIGURE 5 1

PASSAGE PATTERN — COHO

John Day Dam, 1988

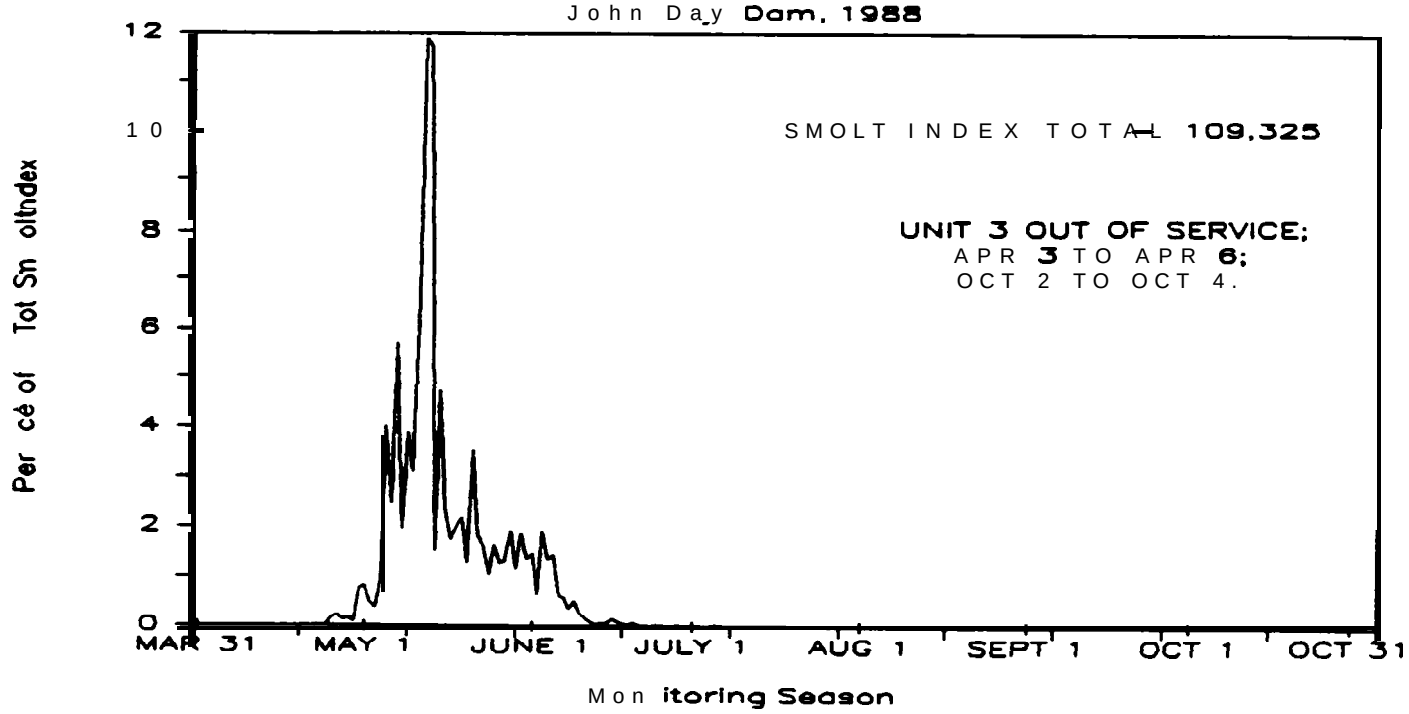


FIGURE 5 2

PASSAGE PATTERN — SOCKEYE

John Day Dam, 1968

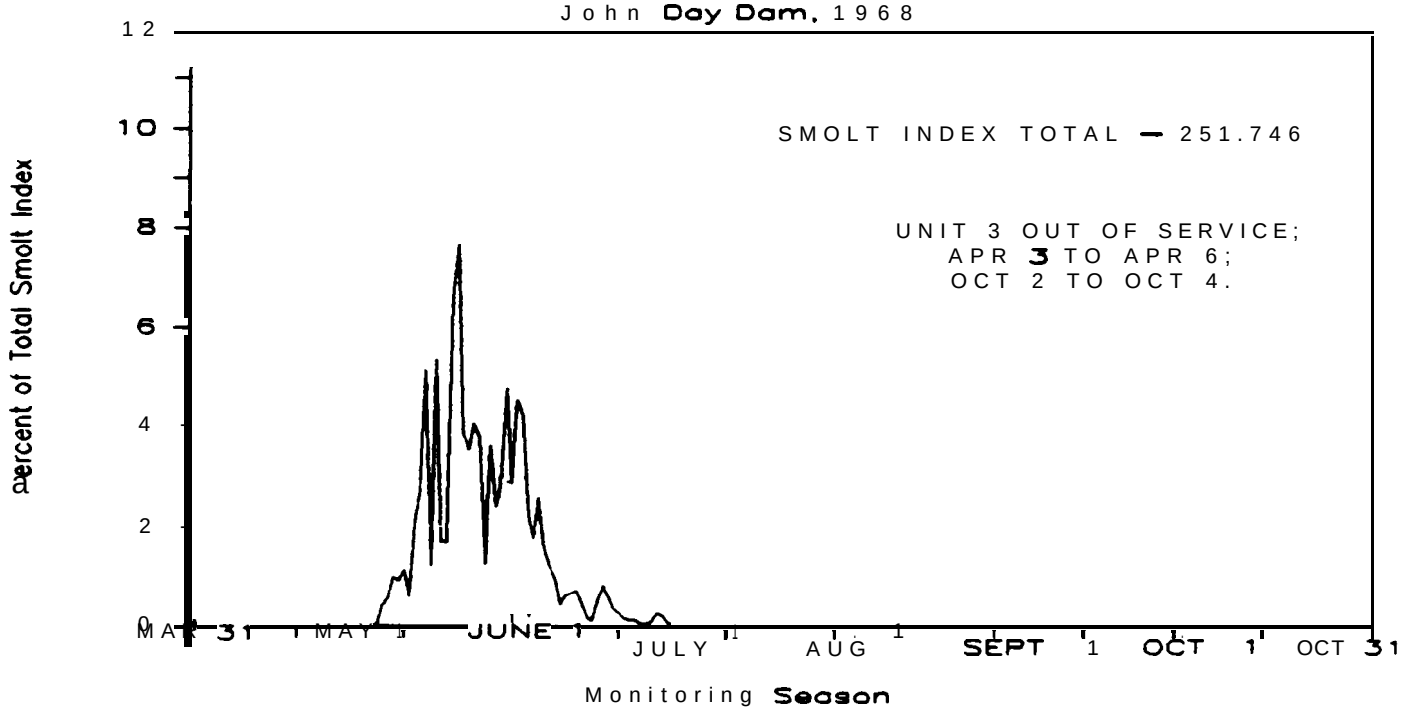


FIGURE 53

APPENDIX D
BONNEVILLE DAM - 1988

TOTAL RIVER FLOW & SPILL-BONNEVILLE DAM

MARCH 15 - JUNE 30

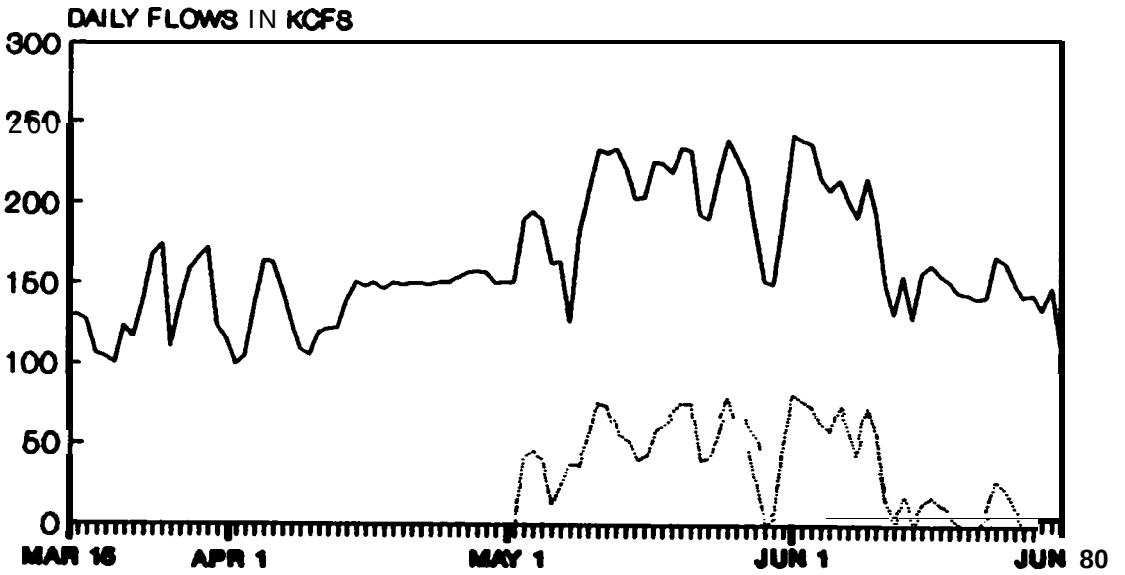


FIGURE 1

TOTAL RIVER FLOW-BONNEVILLE DAM

JULY 1 - NOVEMBER 30

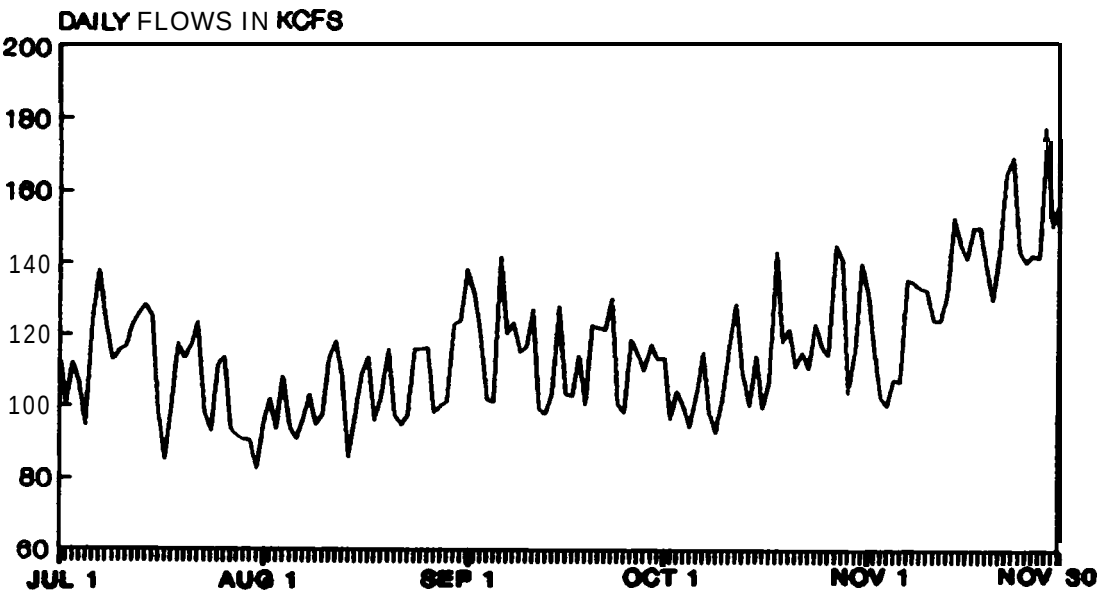


FIGURE 2

POWERHOUSE DISCHARGE-BONNEVILLE DAM
MARCH 15 - JUNE 30

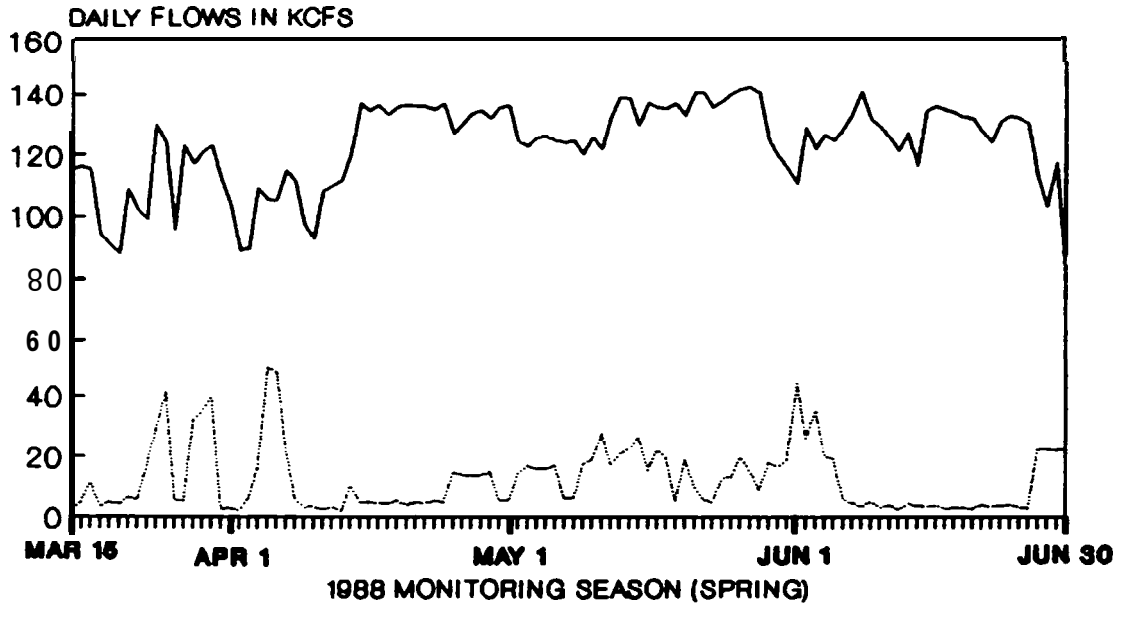


FIGURE 3

POWERHOUSE DISCHARGE-BONNEVILLE DAM
JULY 1 - NOVEMBER 30

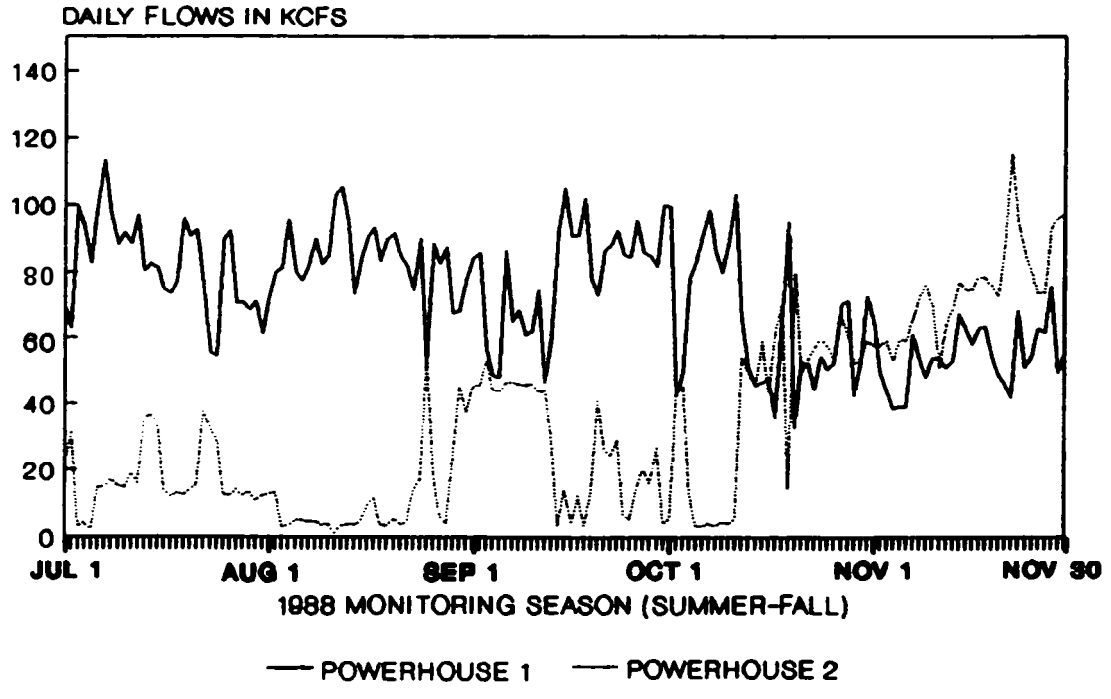


FIGURE 4

UNIT 9 DISCHARGE-BONNEVILLE DAM

MARCH 16 - JUNE 30

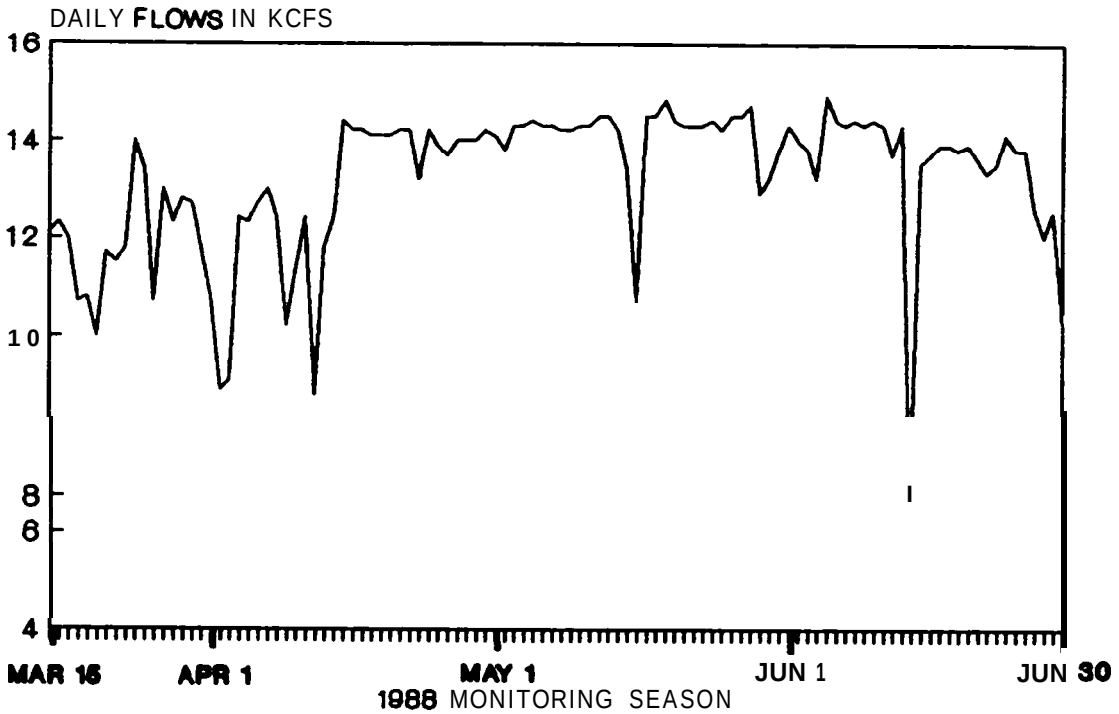


FIGURE 5

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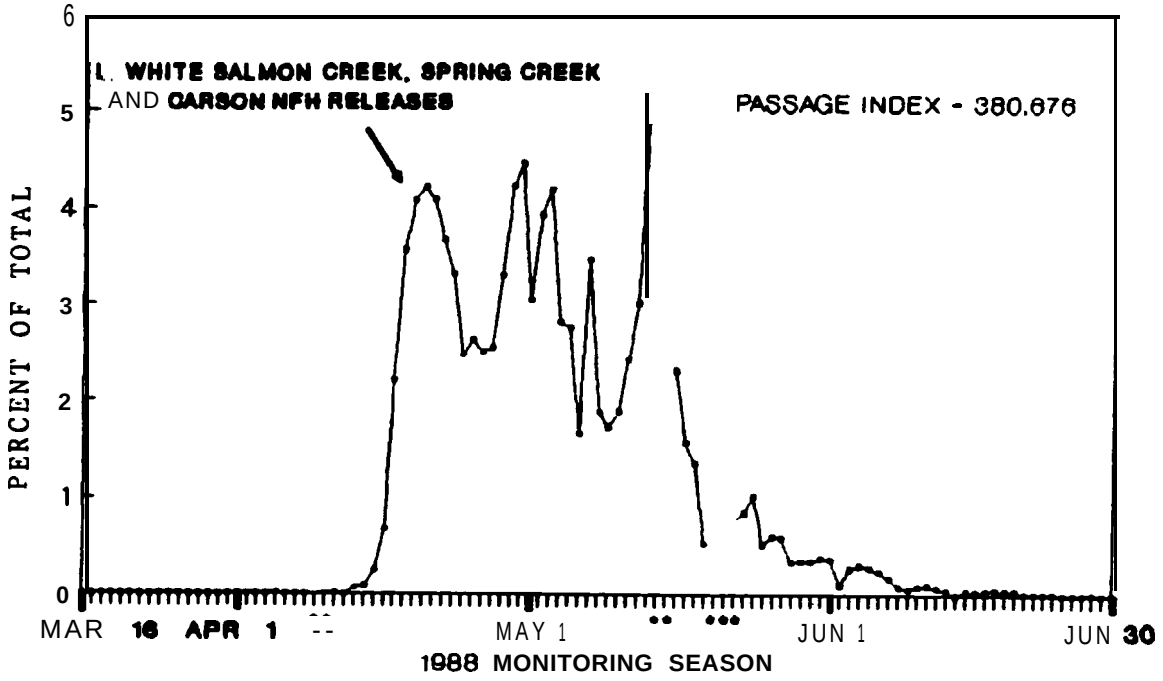
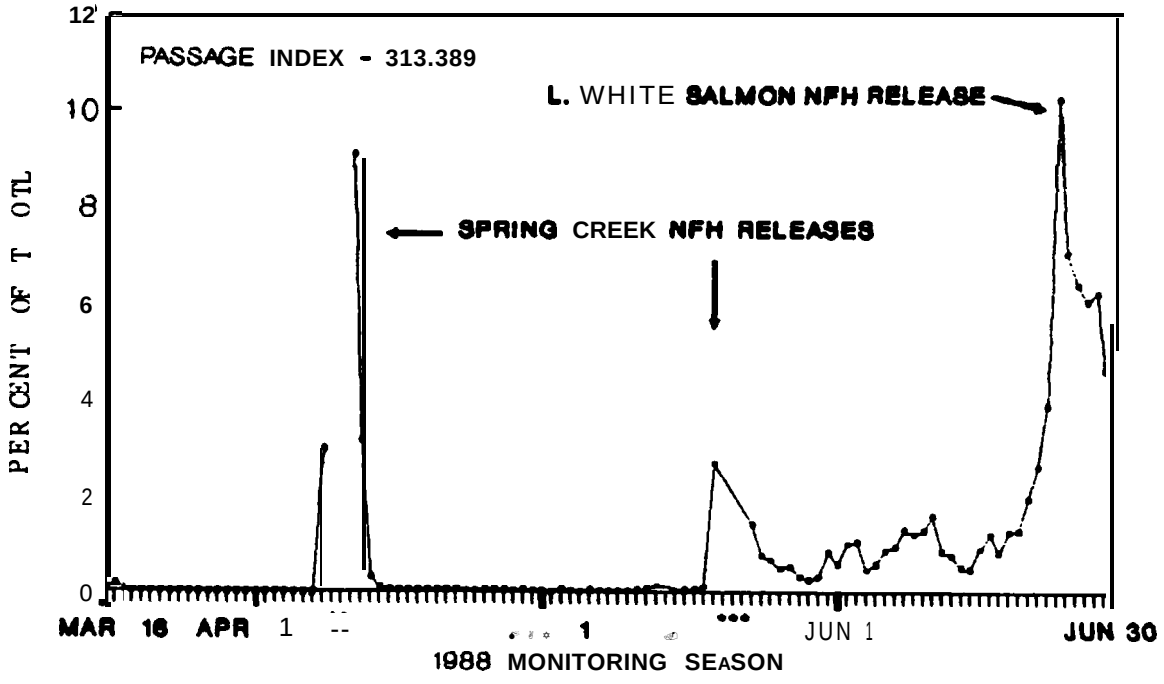
CAPTURE PATTERN, YEARLING CHINOOK
BONNEVILLE DAM, PH#1, GATEWELL 9B



- NO SAMPLE: APR 9.10, MAY 20,21 8 22.
- PARTIAL SAMPLE (<20 HRS.): MAY 14 & 15.

FIGURE 6

CAPTURE PATTERN, SUBYEARLING CHINOOK
BONNEVILLE DAM, PH#1, GATEWELL 9B

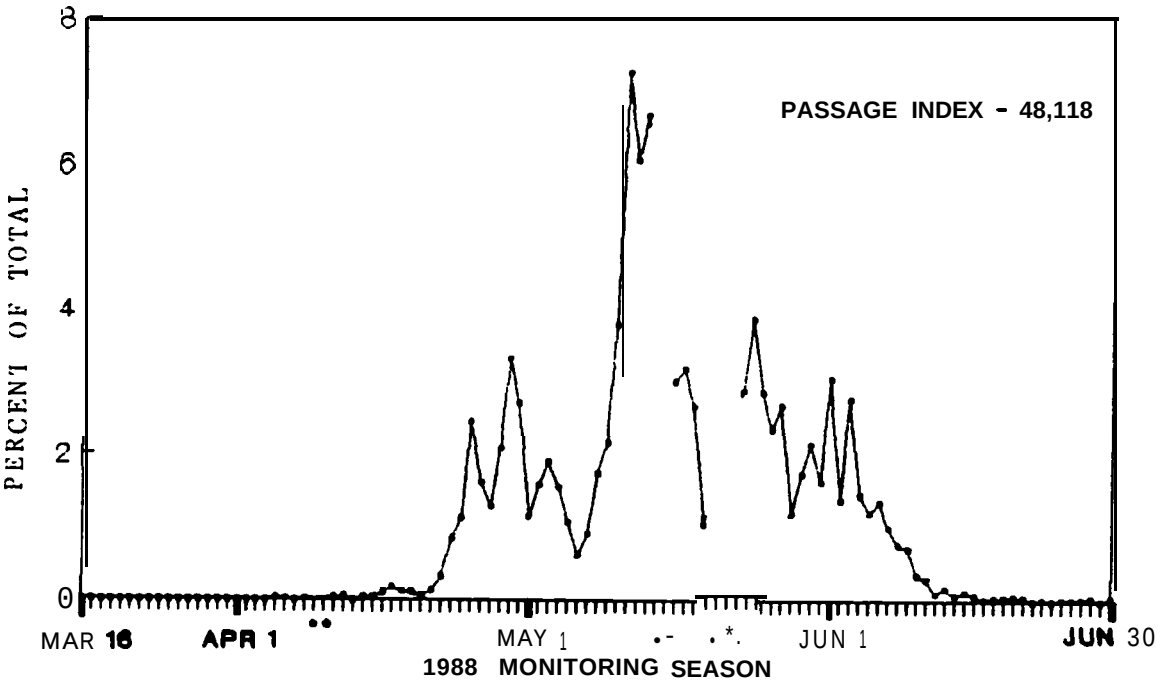


•NO SAMPLES: APRIL 9,10, MAY 20,21 8 22.
•PARTIAL SAMPLES (<20 HRS): MAY 14 & 13

FIGURE 7

CAPTURE PATTERN, STEELHEAD

BONNEVILLE DAM, PH#1, GATEWELL 9B

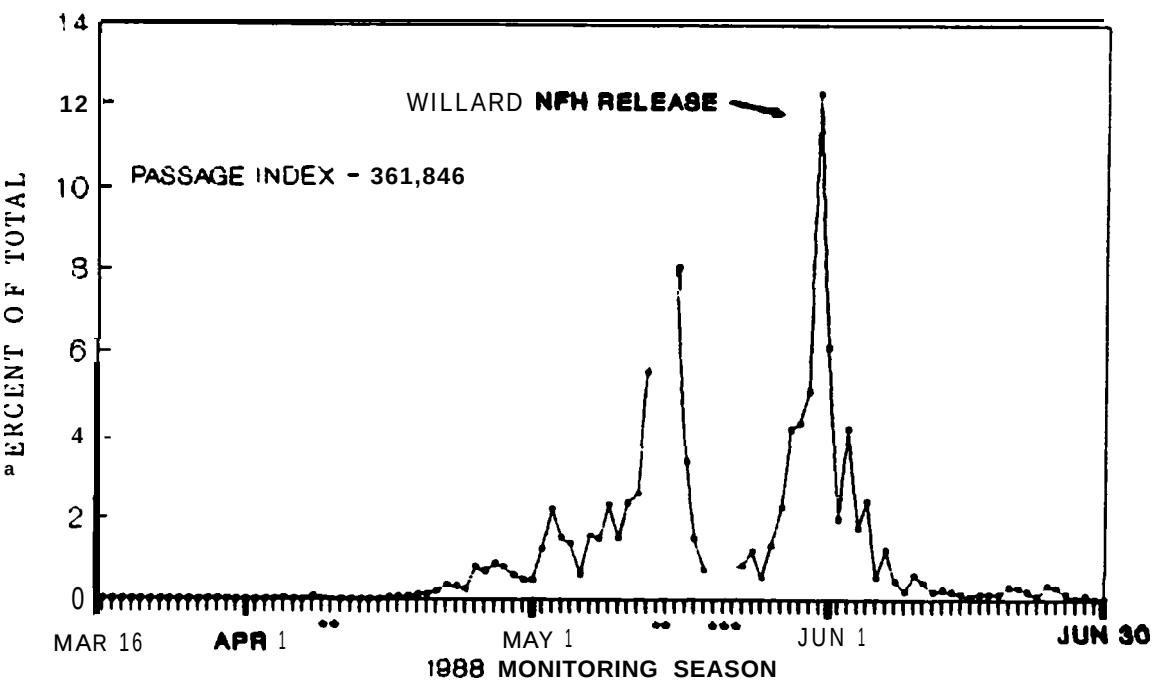


•NO SAMPLES: APRIL 9.10, MAY 20,21 8 22.
● PARTIAL SAMPLES(<20 HRS.): MAY 14 & 15

FIGURE 8

CAPTURE PATTERN, COHO

BONNEVILLE DAM, PH#1, GATEWELL 9B

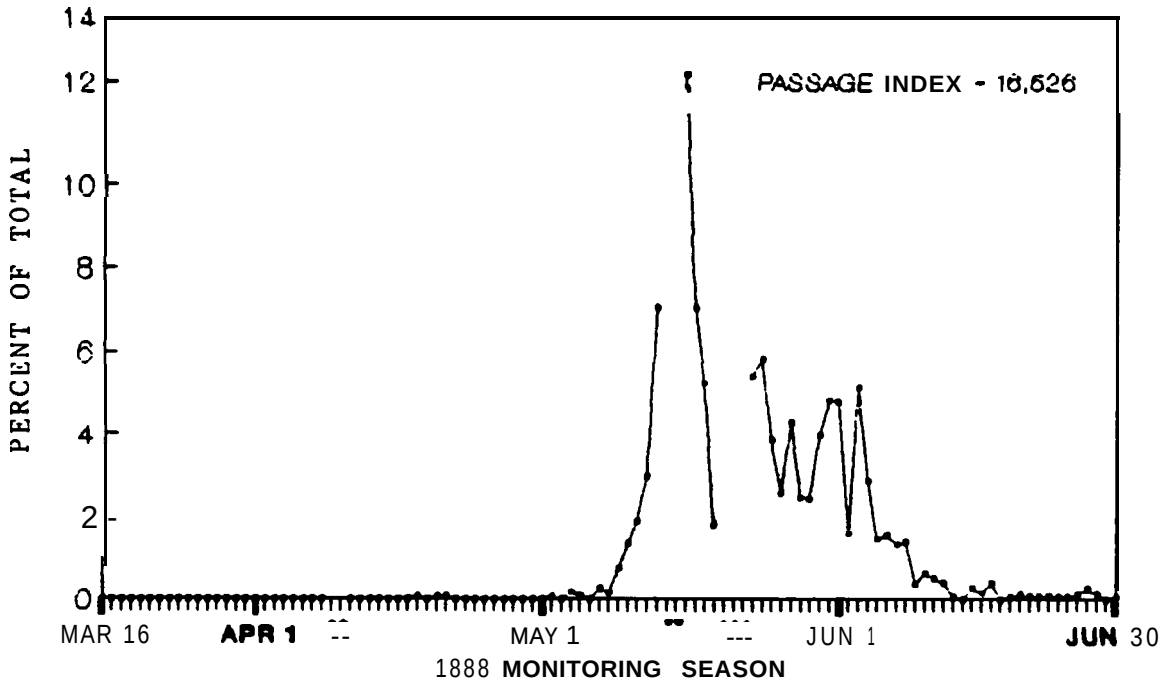


•NO SAMPLES: APRIL 9,10, MAY 20.21 & 22.
•PARTIAL SAMPLES('20 HRS.): MAY 14 & 15

FIGURE 9

CAPTURE PATTERN, SOCKEYE

BONNEVILLE DAM, PH#1, GATEWELL 9B



•NO SAMPLES: APRIL 9,10, MAY 20,21 & 22.
'PARTIAL SAMPLES(<20 HRS.): MAY 14 & 15

FIGURE 10

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CAPTURE PATTERN, YEARLING CHINOOK

BONNEVILLE DAM, PH#1 DSM SAMPLER

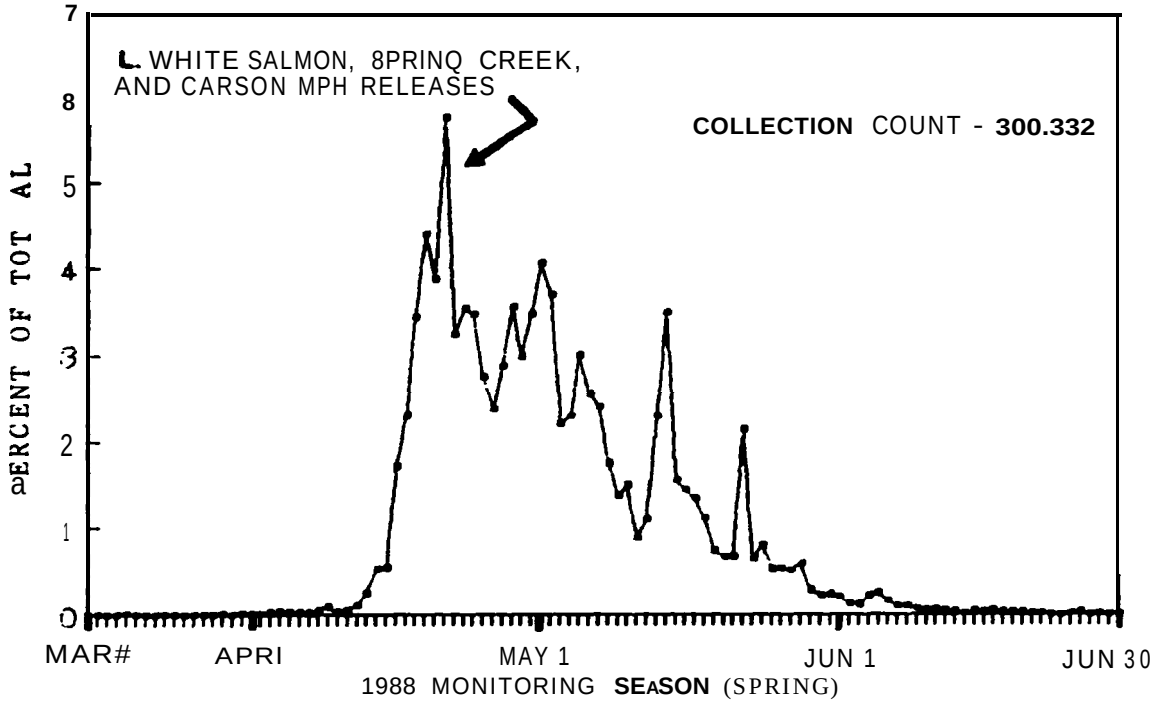


FIGURE 11

CAPTURE PATTERN, YEARLING CHINOOK

BONNEVILLE DAM, PH#1 DSM SAMPLER

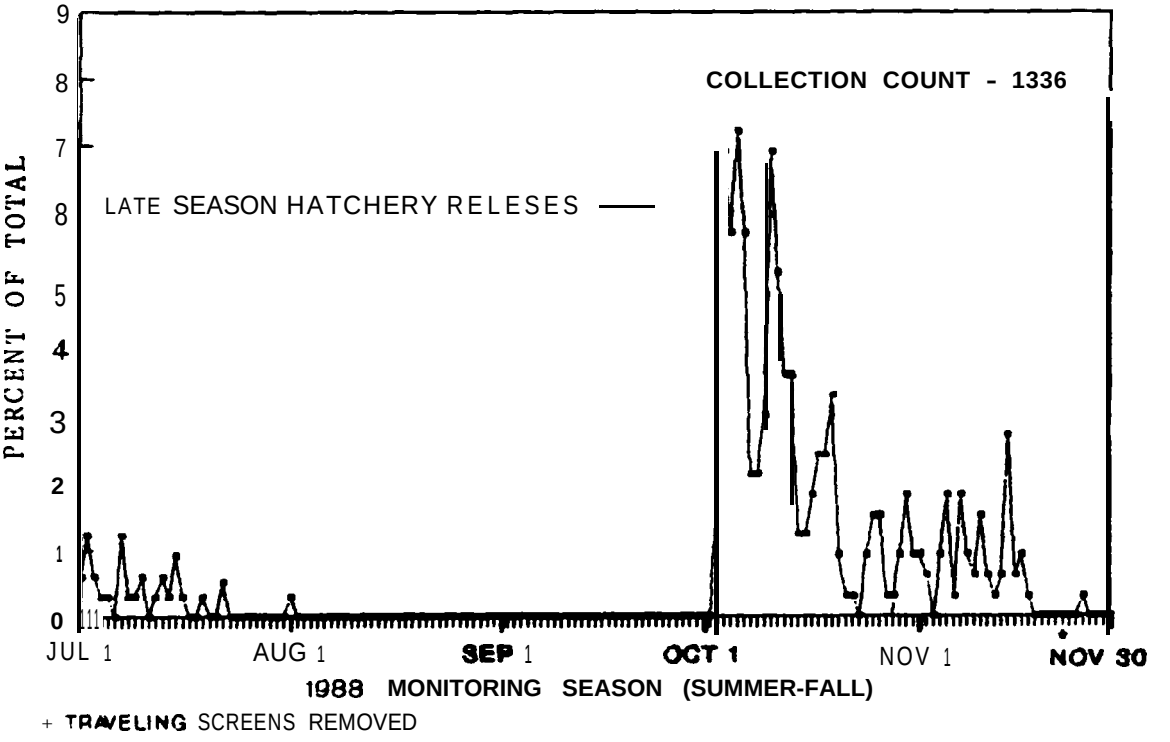


FIGURE 12

CAPTURE PATTERN, SUBYEARLING CHINOOK

BONNEVILLE DAM, PH#I DSM SAMPLER

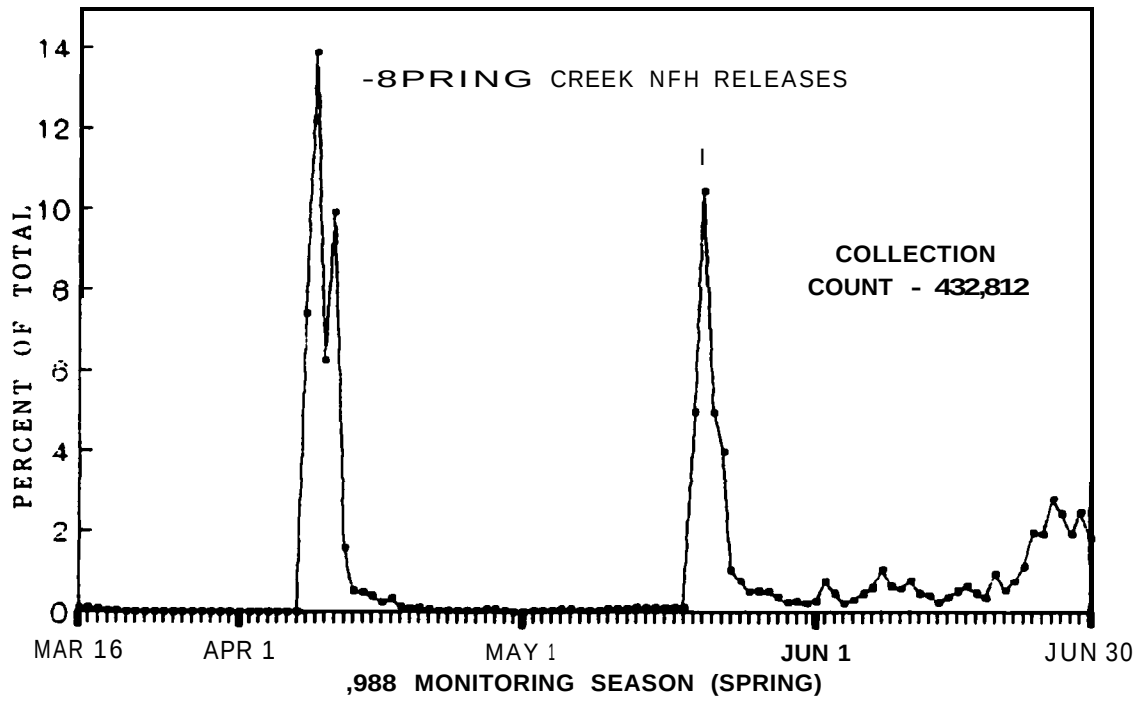
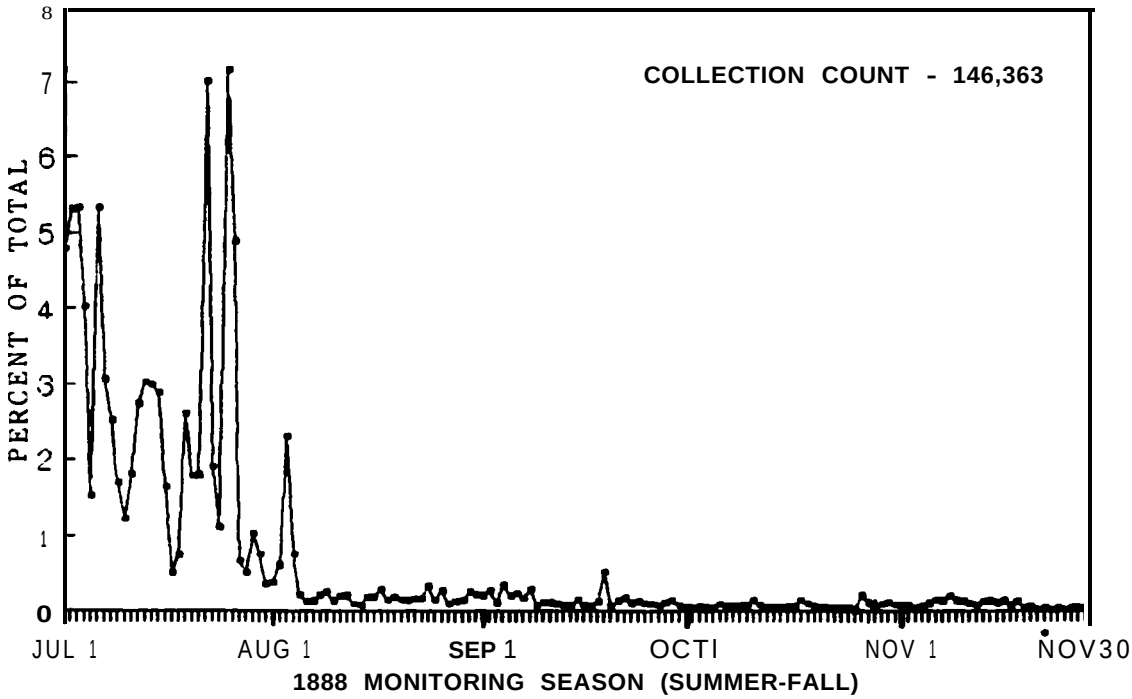


FIGURE 13

CAPTURE PATTERN, SUBYEARLING CHINOOK

BONNEVILLE DAM, PH#I DSM SAMPLER



● TRAVELING SCREENS REMOVED

FIGURE 14

CAPTURE PATTERN, STEELHEAD
BONNEVILLE DAM, PH#1 DSM SAMPLER

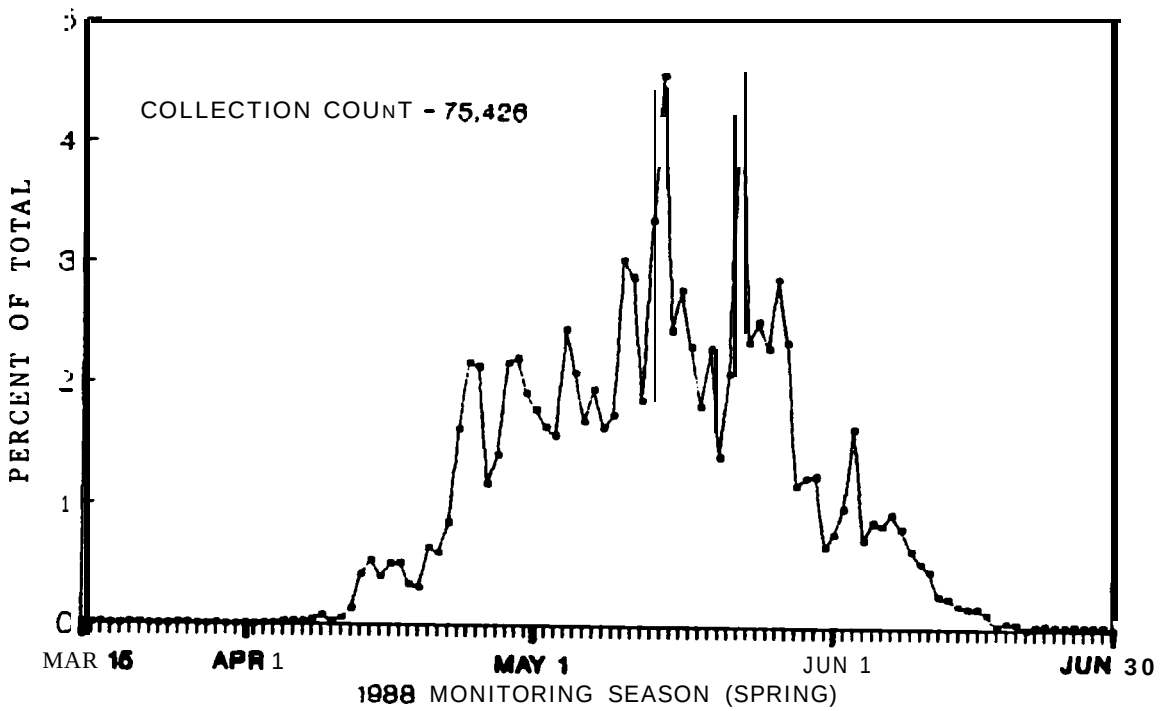


FIGURE 15

CAPTURE PATTERN, STEELHEAD
BONNEVILLE DAM, PH#1 DSM SAMPLER

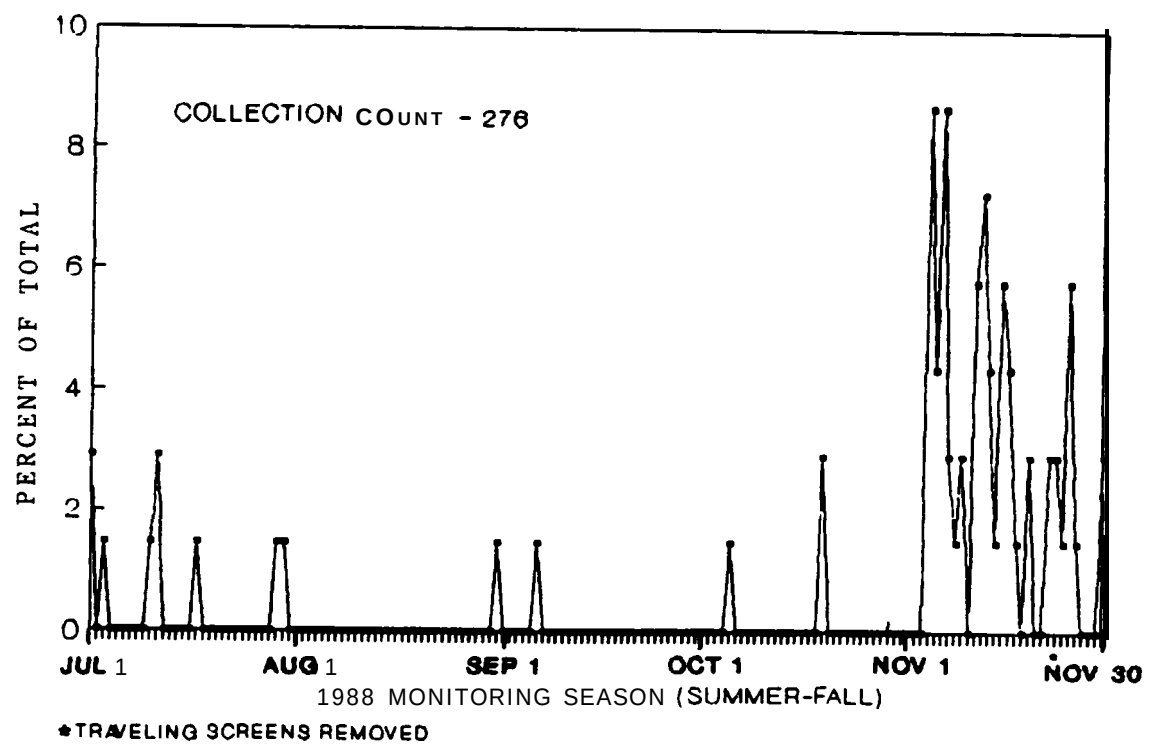


FIGURE 16

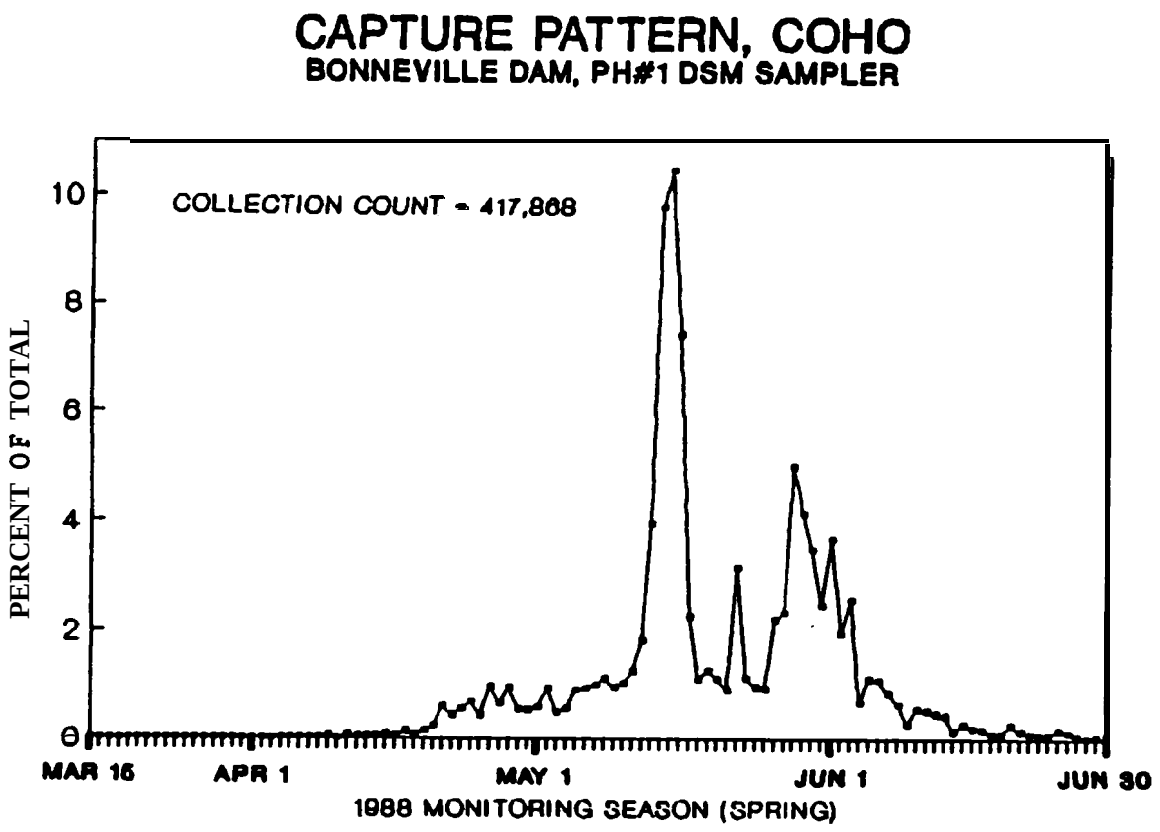


FIGURE 17

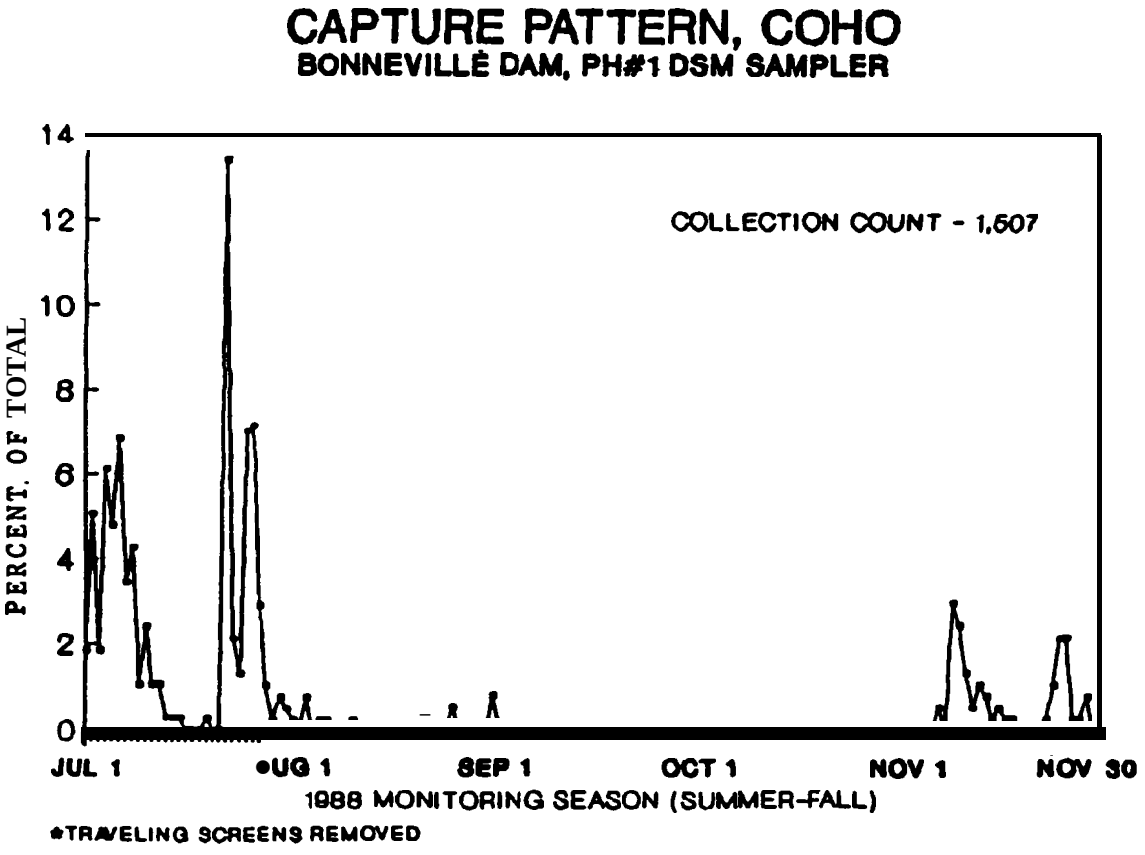


FIGURE 18

CAPTURE PATTERN, SOCKEYE

BONNEVILLE DAM, PH#1 DSM SAMPLER

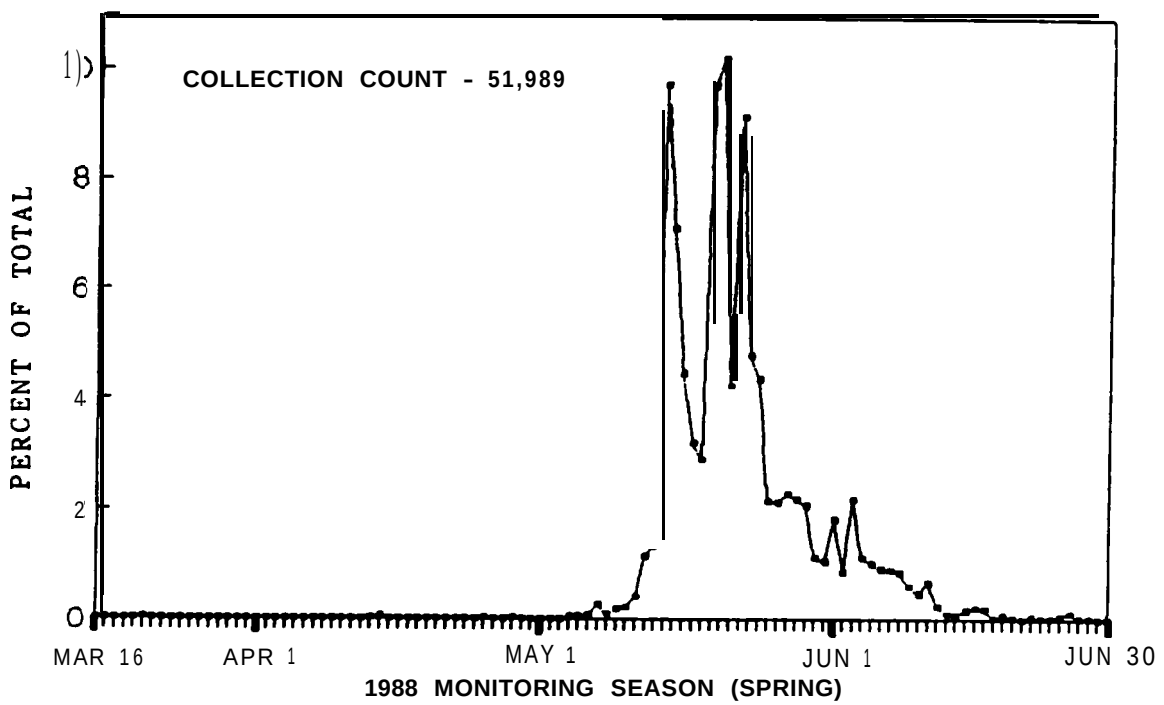


FIGURE 19

CAPTURE PATTERN, SOCKEYE

BONNEVILLE DAM, PH#I DSM SAMPLER

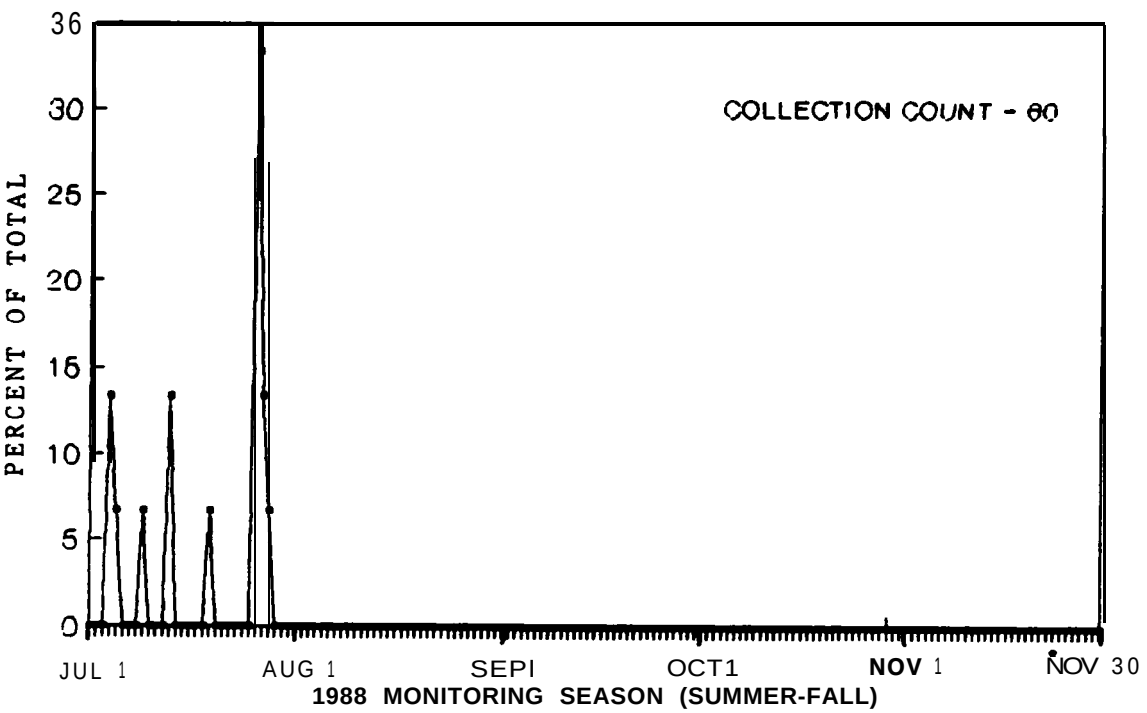


FIGURE 20

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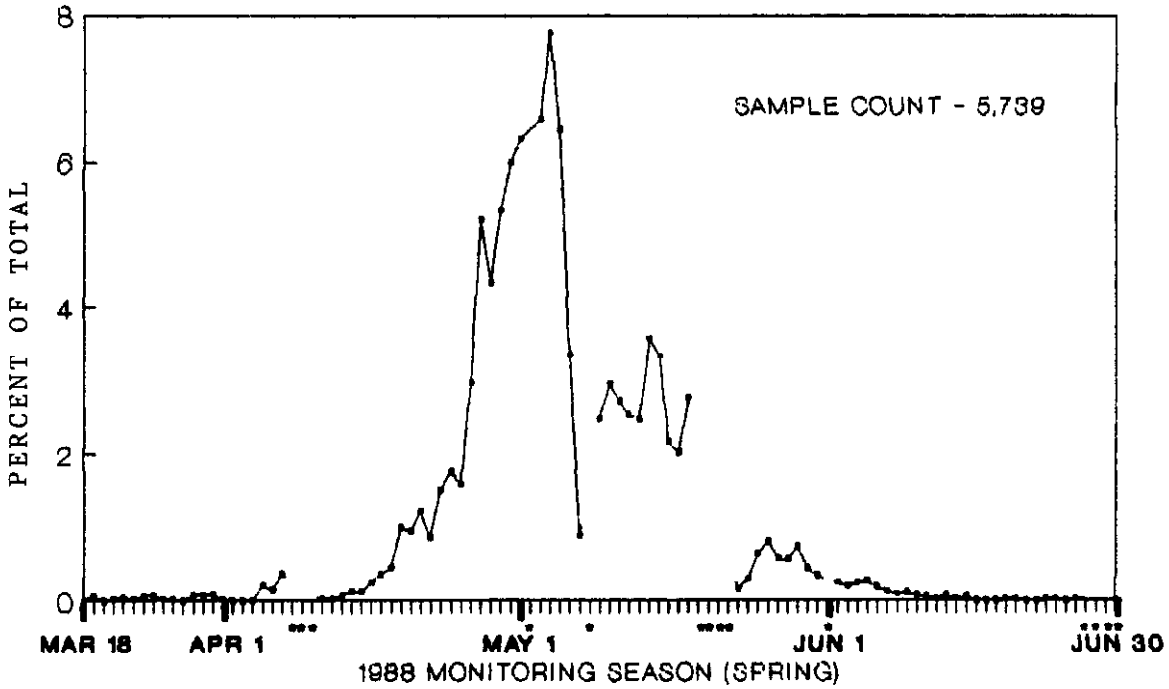
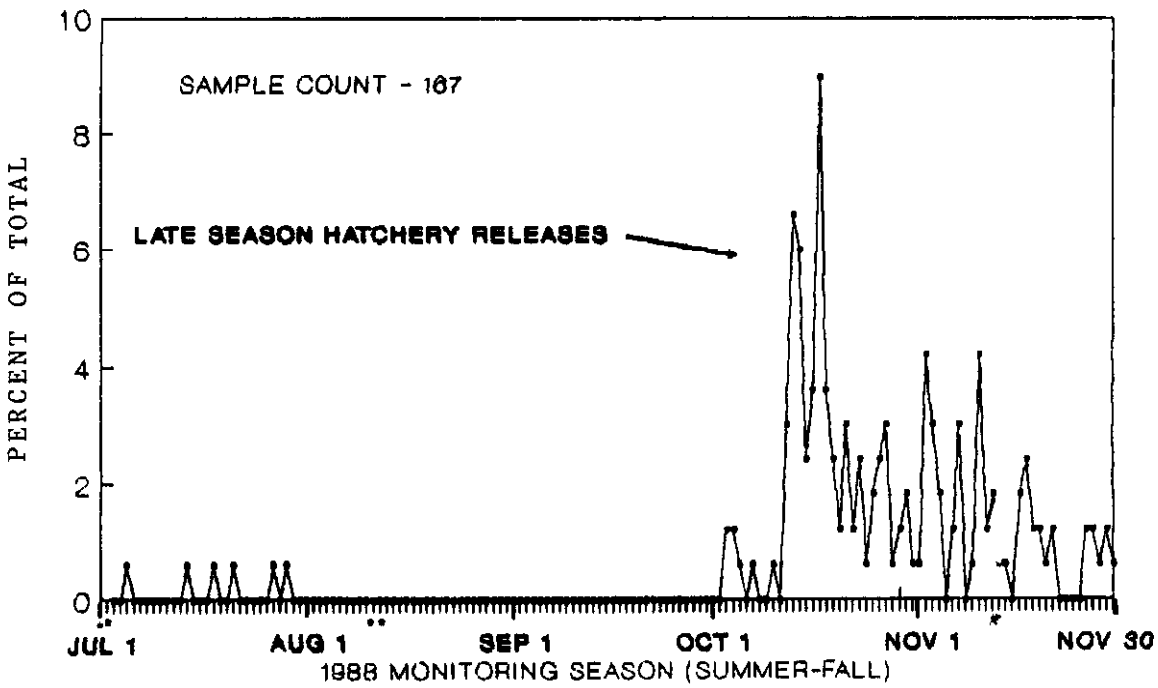
CAPTURE PATTERN, YEARLING CHINOOK
BONNEVILLE DAM, PH#2 DSM SAMPLER



•PARTIAL (<20 HRS.) OR NO SAMPLES:
APR 8,9,10, MAY 2,8,19,20,21,22, JUNE 1,27,28,29 & 30.

FIGURE 21

CAPTURE PATTERN, YEARLING CHINOOK
BONNEVILLE DAM, PH#2 DSM SAMPLER

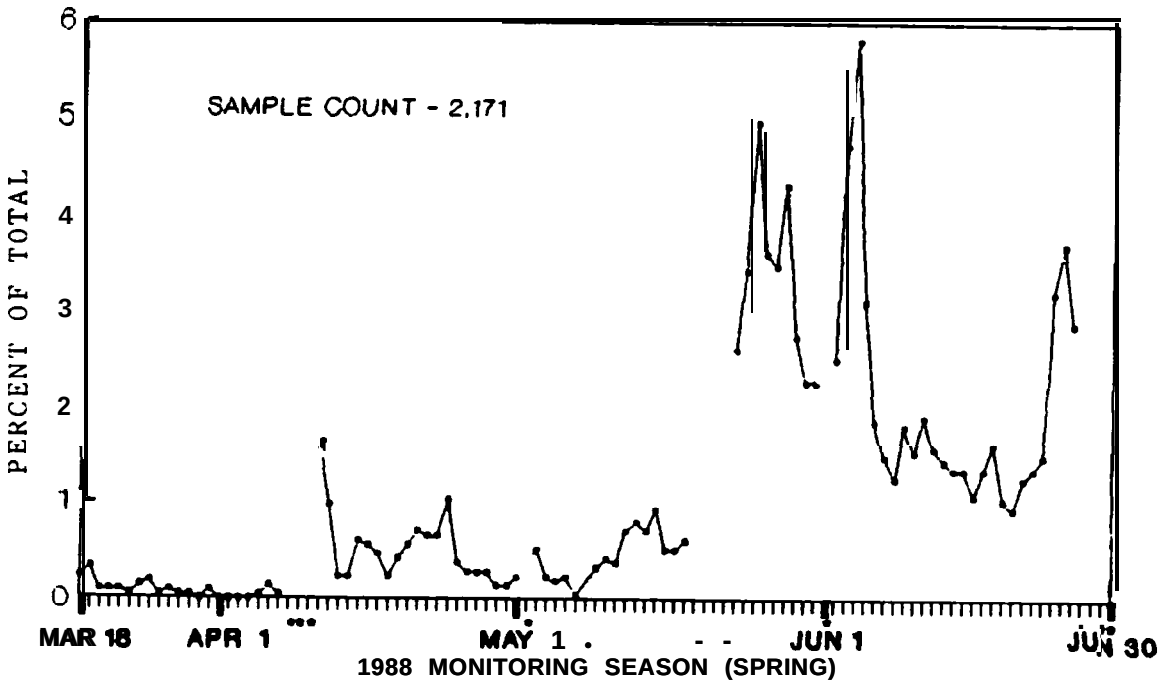


* PARTIAL (<20 HRS.) OR NO SAMPLE; JUL 1,2, AUG 11,12, NOV 13
INCOMPLETE SAMPLES(>20, <24 HRS.);JUL 12,13,14,21,23,24,29, AUG 31, OCT 19.

FIGURE 22

CAPTURE PATTERN, SUBYEARLING CHINOOK

BONNEVILLE DAM, PH#2 DSM SAMPLER

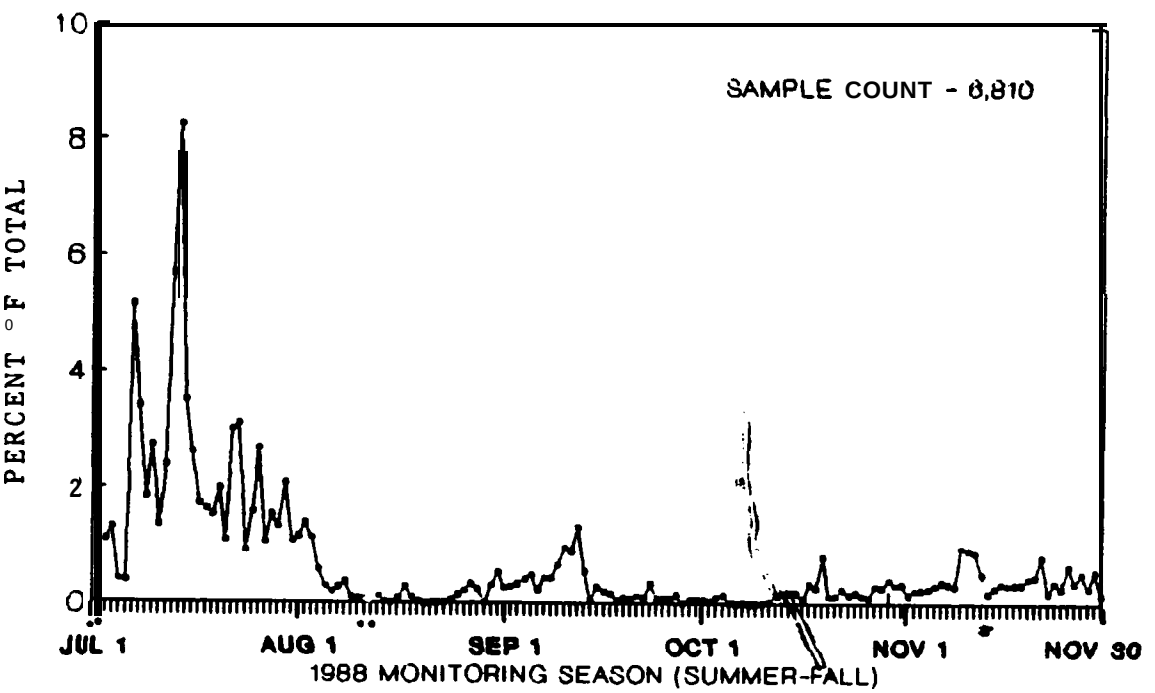


'PARTIAL (<20 HRS.) OR NO SAMPLE: APR 8,9,10. MAY 2,3, 19,20,21,22; JUNE 1,27,28,29,30.

FIGURE 23

CAPTURE PATTERN, SUBYEARLING CHINOOK

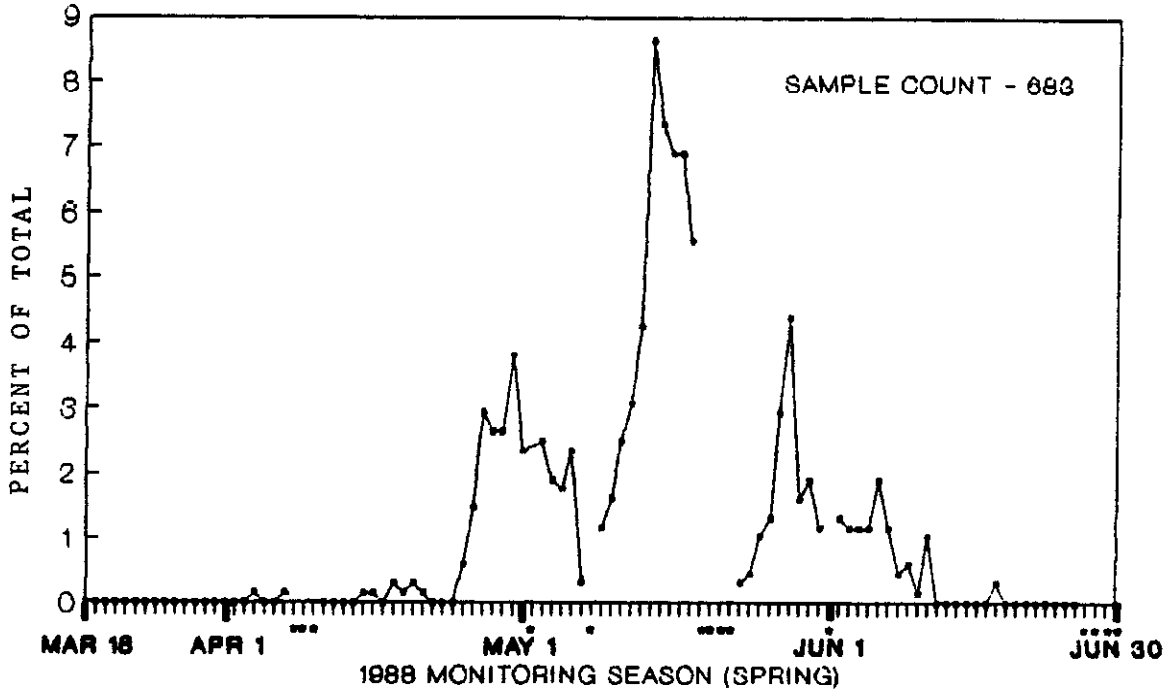
BONNEVILLE DAM, PH#2 DSM SAMPLER



. PARTIAL(>20 HRS.) OR NO SAMPLES; JUL1.2. AUG 11.12. NOV 13.
INCOMPLETE SAMPLES(>20, <24 HRS.);JUL 12,13,14,21,23,24,29, AUG 31, OCT 19.

FIGURE 24

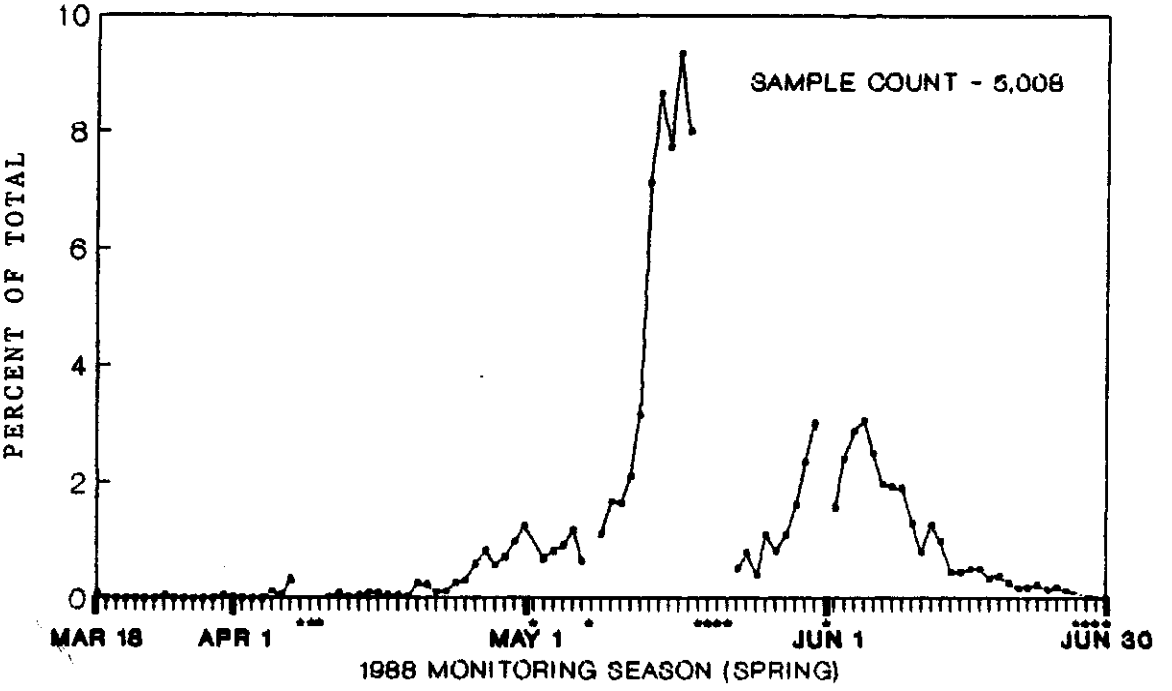
CAPTURE PATTERN, STEELHEAD
BONNEVILLE DAM, PH#2 DSM SAMPLER



*PARTIAL(<20 HRS.) OR NO SAMPLES:APR 8,9,10, MAY 2,8,19,20,21,22, JUNE 1,27,28,29,30

FIGURE 25

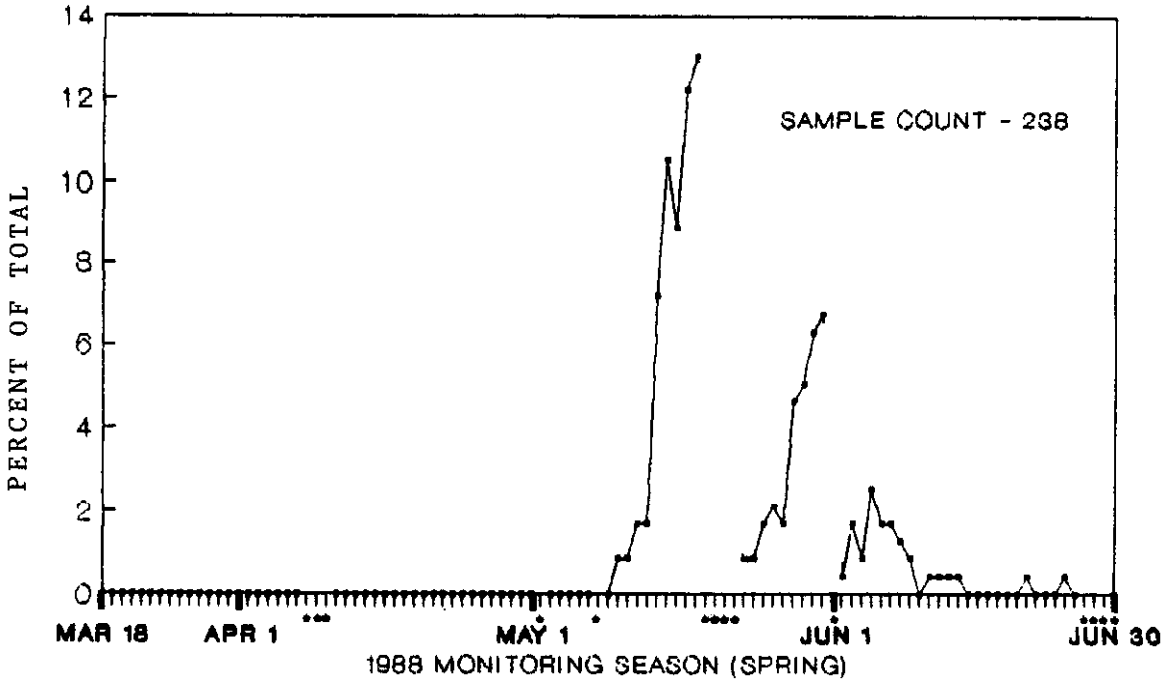
CAPTURE PATTERN, COHO
BONNEVILLE DAM, PH#2 DSM SAMPLER



*PARTIAL(<20 HRS.) OR NO SAMPLES:APR 8,9,10, MAY 2,8,19,20,21,22, JUNE 1,27,28,29,30

FIGURE 26

CAPTURE PATTERN, SOCKEYE
BONNEVILLE DAM, PH#2 DSM SAMPLER



•PARTIAL(<20 HRS.) OR NO SAMPLES:APR 8,9,10,
MAY 2,8,19,20,21,22; JUNE 1,27,28,29,30

FIGURE 27

CUMULATIVE CAPTURE - SPRING MIGRANTS
BONNEVILLE DAM, PH#1 DSM SAMPLER

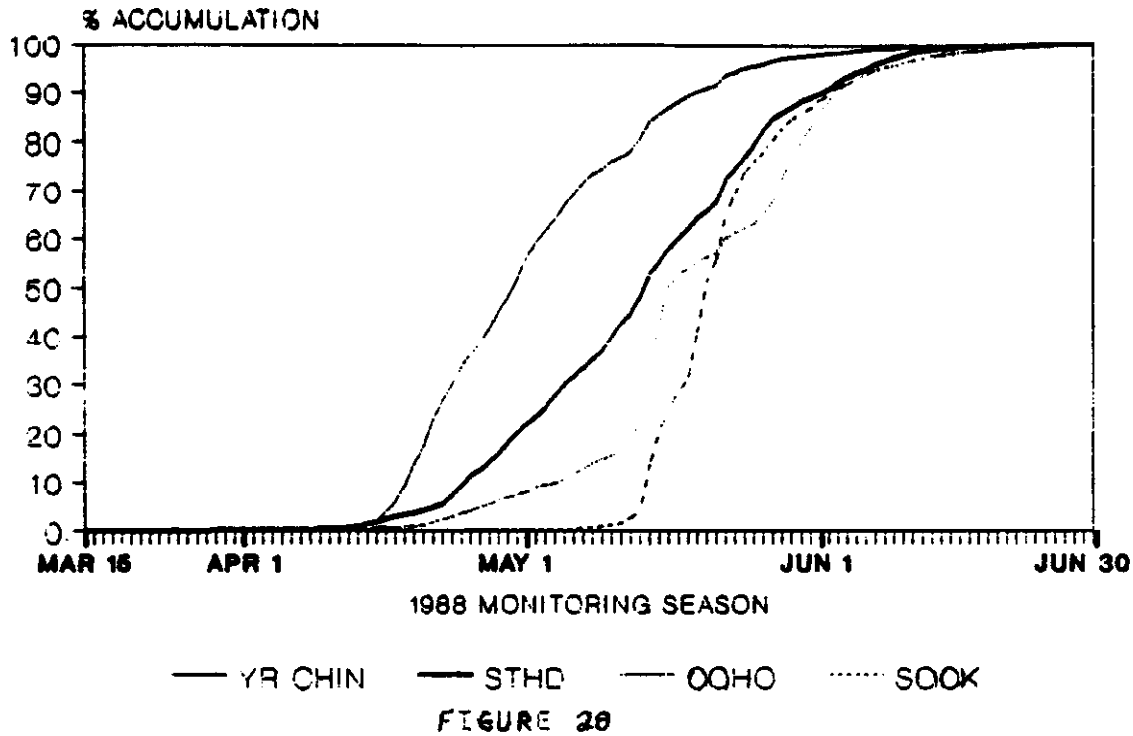


FIGURE 28

CUMULATIVE CAPTURE - SUBYEARLING CHINOOK
BONNEVILLE DAM, PH#1 DSM SAMPLER
MARCH 15 - JUNE 30

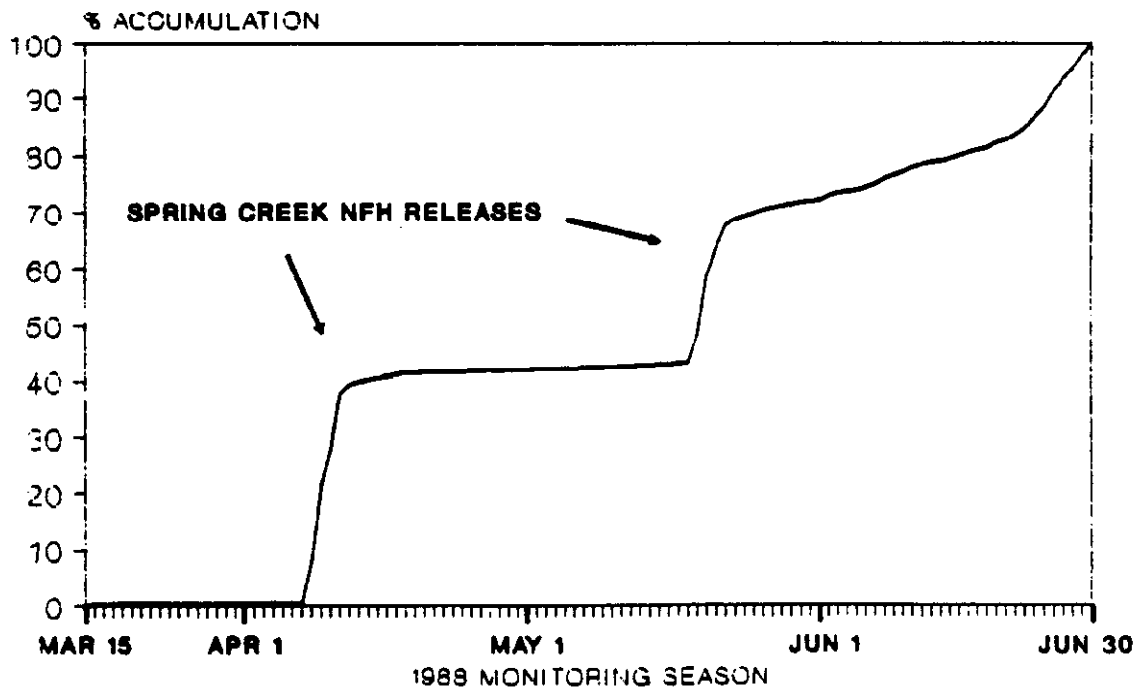
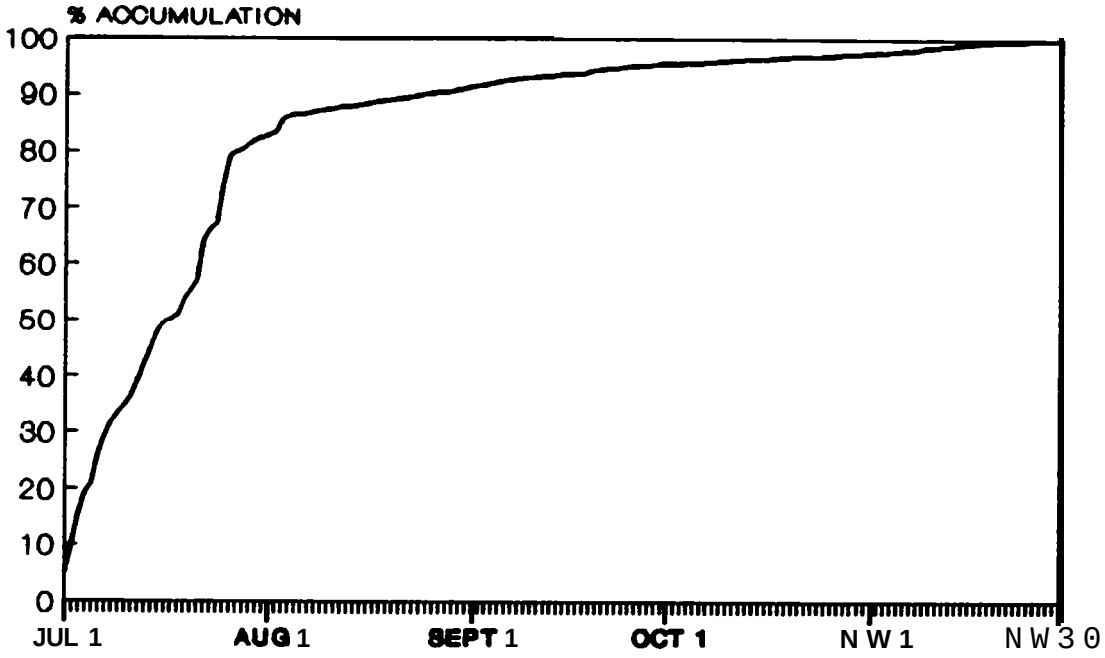


FIGURE 29

CUMULATIVE CAPTURE - SUBYEARLING CHINOOK

BONNEVILLE DAM, PH#1 DSM SAMPLER

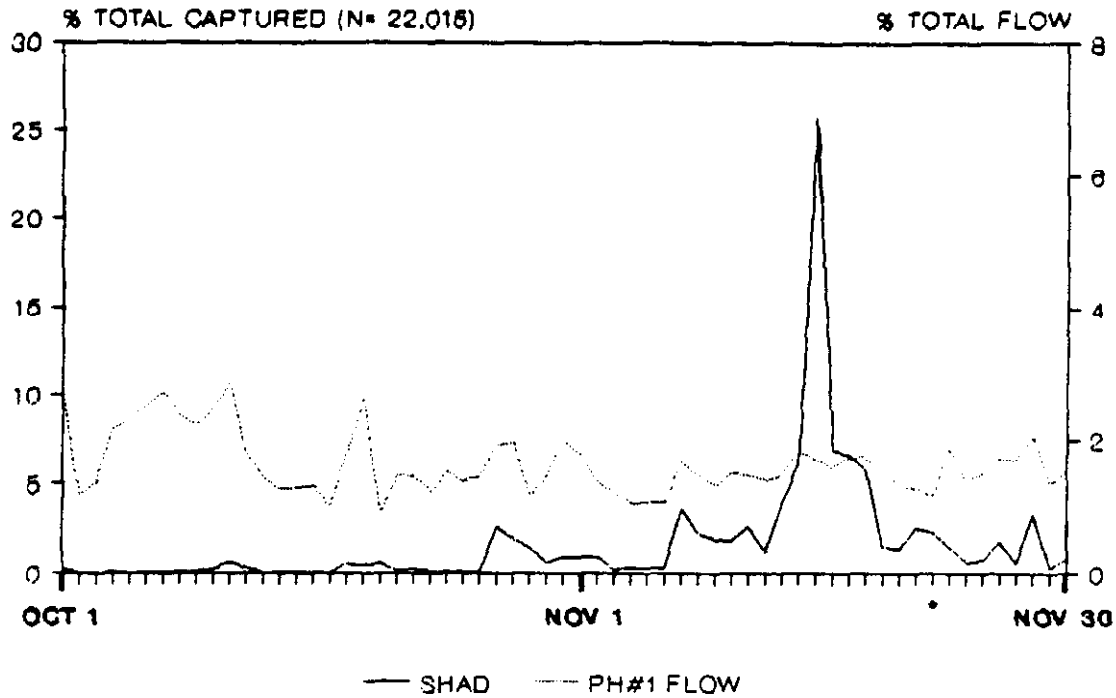
JULY 1 - NOVEMBER 30



1988 MONITORING SEASON

FIGURE 30

CAPTURE PATTERN, JUVENILE SHAD
BONNEVILLE DAM, PH#1 DSM SAMPLER, 1988



*TRAVELING SCREENS REMOVED.

FIGURE 31

CAPTURE PATTERN, JUVENILE SHAD
JOHN DAY DAM, 1988

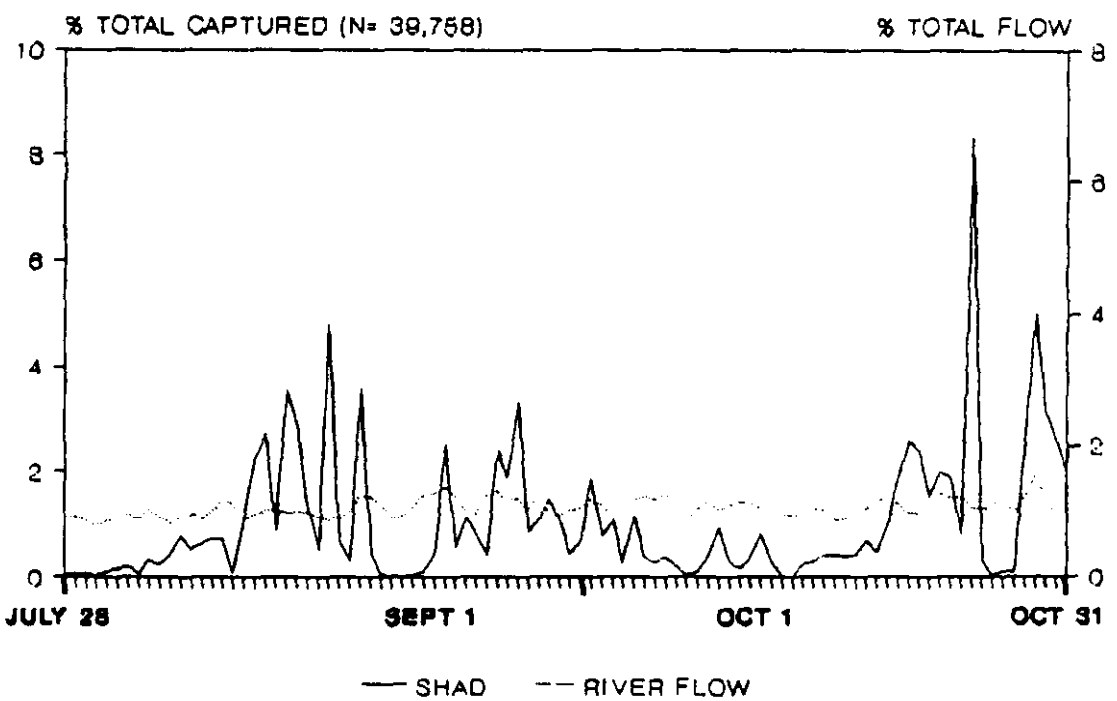


FIGURE 32